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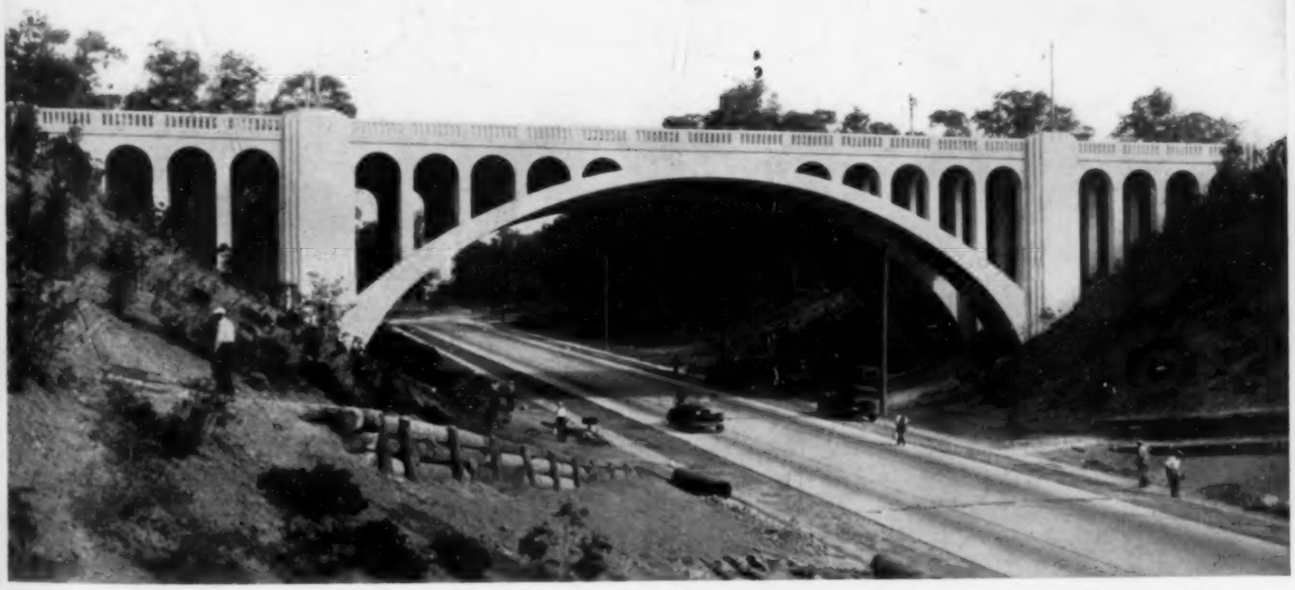

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Volume 6 — AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852 — *Number 11*

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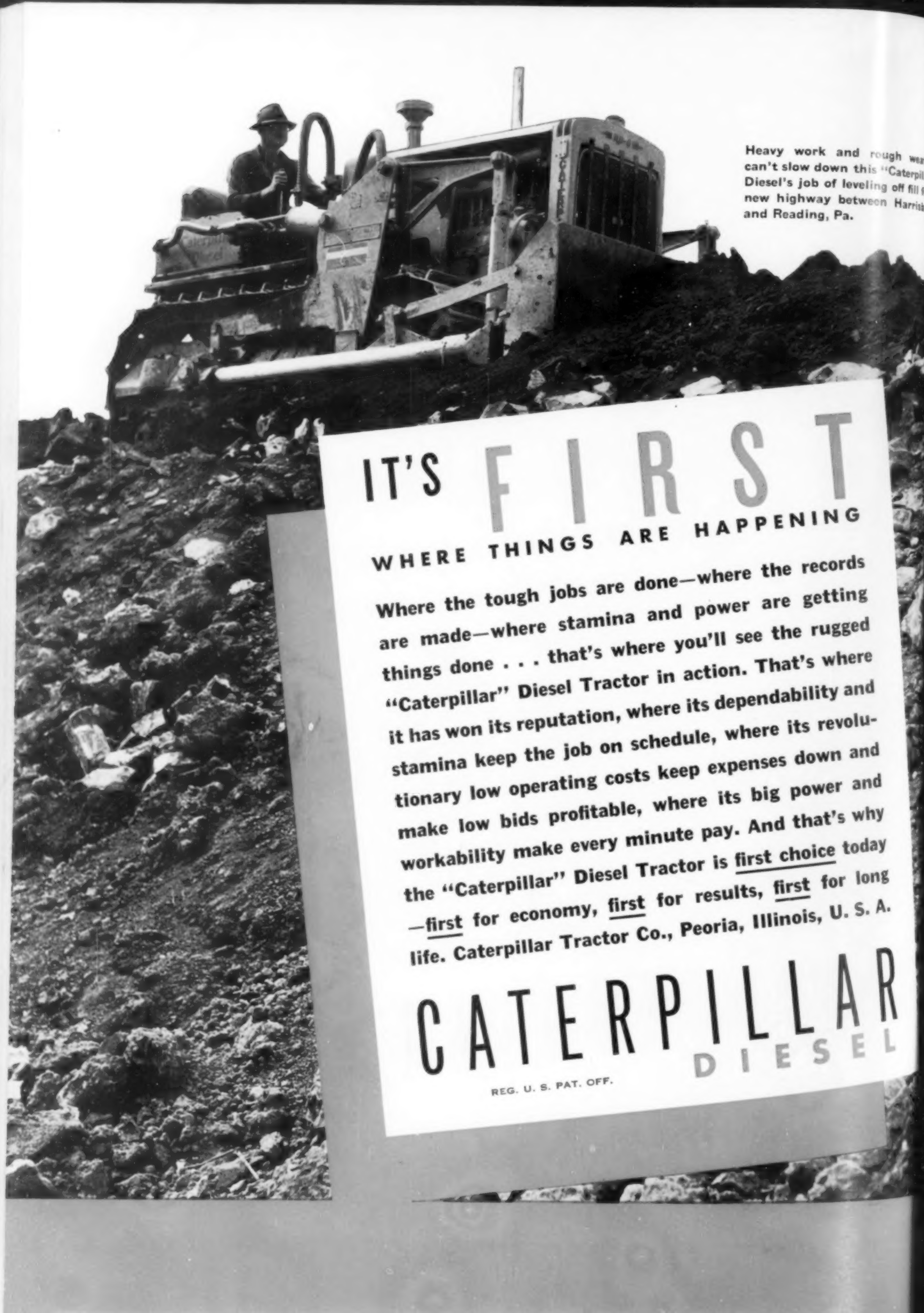
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Among Our Writers

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Number 11

Early Works of Thomas Telford, Engineer

An Account of the Activities of the First 36 Years of His Life, from 1757 to 1793

By John F. Baker, Assoc. M. Am. Soc. C.E.
and John Armitage
Respectively Professor of Civil Engineering, University of Bristol, Bristol, England,
and Editor, "Squash Rackets and Fives," London

Pioneer in bridge, canal, and road construction, Thomas Telford occupies a leading place among early civil engineers. He was born in Scotland at the very threshold of the industrial revolution, when the need for better means of communication was beginning to attain importance. In his structures, which were notable for boldness of design based for the first time upon the strength of materials as determined experimentally, Telford made novel use of both wrought-iron and cast-iron. This article, dealing with Telford's early life and works, includes his career as county engineer of Salop and the establishing of his engineering reputation through the design and construction of the 112-mile Ellesmere Canal. It is abstracted from the first of a group of four interesting lectures on Telford's life and works given by Professor Baker at the University of Bristol. The remaining abstracts will appear in forthcoming issues.

Thomas Telford, who died just over a hundred years ago, was a pioneer in the field of civil engineering. He was responsible for an immense amount of canal, road, and bridge construction in England, Wales, and Scotland. During his life, he turned his attention to many different branches of engineering, and in nearly every case he was breaking new ground. Not the least of his great genius was his ability to see clearly the core of the problem he was asked to solve.

Starting life as a mason, Telford always took great pride in using masonry to the best advantage. He was, however, far from being a specialist. Opportunities for work in Dumfries—the wild and sparsely populated county in Scotland where he was born—did not allow the employment of different men for different building operations. Every man had to acquaint himself with every detail of every piece of work, and such experience was invaluable. Telford realized this, and more than a hundred years ago gave advice which is as sound today as it was then. He said, "Youths of respectability and competent education, who contemplate civil engineering as a profession are seldom aware how far they ought to descend in order to found the basis of future elevation.... How can a man give judicious directions unless he possesses personal knowledge of the details requisite to effect its ultimate purpose in the best and cheapest manner?" Telford expressed this view when the modern science of civil engineering was still in its infancy and when many years were still to pass before it should achieve the dignity of being regarded as suitable for study at a university. If Telford's warning was necessary then, it is doubly so today, when the young man who has passed successfully through a theoretical training, too often regards himself as a full-fledged engineer.

Thomas Telford was born on August 9, 1757. The story of his childhood and the days when he was a young man in Scotland is briefly told in his invaluable autobiography, *The Life of Thomas Telford, Civil Engineer*. This book also gives a detailed description of his engineering work. The story of his childhood, like that of many other great men, is a story of poverty at the start and the gradual triumph of a determined personality over hardships. John Telford, father of Thomas, was a shepherd on the sheep farm of Glendinning near the village of Westerkirk, which lies in Eskdale, County of Dumfries, Scotland. Within a year after Thomas's birth, John Telford died. In this way an influence, which might have made Thomas Telford a shepherd for life, was removed at the start. There was nothing romantic about Telford's boyhood. In his youth he herded cattle to aid the slender resources

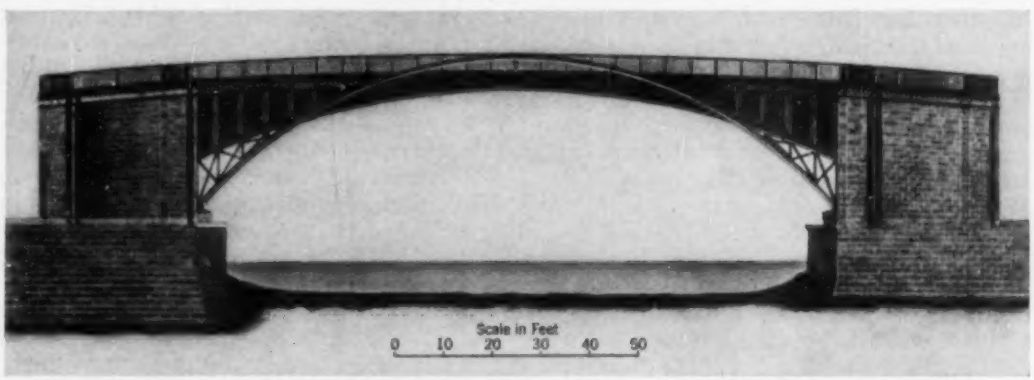


Fig. 1. The Buildwas Bridge Over the River Severn
Telford's First Cast-Iron Bridge, Built in 1795 and 1796, Had an Arch Span of 130 Ft

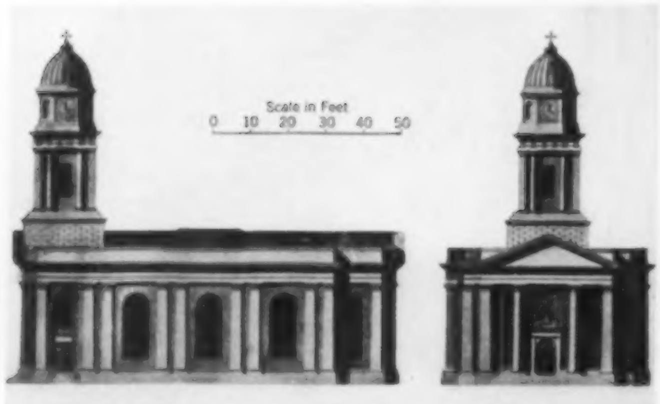


Fig. 2. The Church of St. Mary Magdalen Is Still Standing in the Town of Bridgenorth

Telford Was Architect and Builder of This Structure, Which Is 124 Ft Long and 67 Ft Wide. The Tower Is 115 Ft High

of his home. In addition, he and his mother received some assistance from a cousin named Jackson, so that the boy was able to attend the village school at Westerkirk.

A Stone-Mason's Apprentice at the Age of 15

When he was about fifteen years old, Telford was sent to Lochmaben as an apprentice to a stone-mason. Disliking it, or being badly treated, he ran away. However, through the influence of his cousin, he was able to continue his apprenticeship—this time in Langholm, with one Andrew Thomson. The period was a busy one for the mason as the farmhouses on the estate of the Duke of Buccleuch were being modernized, and there were also bridges to be built in place of old horse tracks. Telford thus gained valuable experience from the start.

When his apprenticeship was over, he continued to work at Langholm for one shilling and sixpence a day, helping in the reconstruction of the town and the building of a new bridge. Apparently during this period he became a first-class craftsman and was employed especially in hewing gravestones and other ornamental work. While at Langholm he became acquainted with a Miss Pasley, who took a fancy to him and often loaned him books from her library. Thus his education was not neglected.

In 1780, when in his twenty-third year, he left Langholm and set out for Edinburgh. At this time he already had a background of some years' practical experience. He also seems to have realized that there was nothing further to be gained by remaining in Dumfries. Telford stayed in Edinburgh about two years. There he found constant employment, since the town was being rebuilt and there was a demand for skilled masons. Although this time had been spent very profitably, studying the fine architectural structures that surrounded him, he decided in 1782 to move again, this time to London. "Having acquired," he writes, "the rudiments of my profession, I considered that my native country afforded few opportunities of exercising it to any extent, and therefore judged it advisable (like many of my countrymen) to proceed southward, where industry might find more employment and be better rewarded." No sentence could sum up better the essential characteristics of Telford's nature than this. All his life he was practical and to the point, capable of making a quick, firm decision and afterwards expressing it by action.

Through Miss Pasley, Telford received a letter of introduction to her brother, and through the latter further letters to Sir William Chambers, the architect of Somerset House, which was being built at that time, and to Robert Adam. Good hewers were in demand at Somerset House, and Telford obtained employment there without much difficulty. Unfortunately little is known of his brief stay in London. But it is clear from his letters that, although he was fast becoming a first-class mason, he was impatient to better his position. Telford had good friends in London: Robert Adam continued to take an interest in him, and he met William Pulteney, who a year or two later was to give him his first important post.

In July 1784 Telford was at Portsmouth, superintending the building of a house and other offices for the commissioner at the dockyard. There for the first time he saw under construction wharf walls, graving docks, and similar works which later were to be his principal occupation for many years. Apparently he kept very busy while at Portsmouth, not only with his work but in study. In a letter of that period he wrote, "The mode of making mortar in the best way led me to inquire into the nature of lime. Having, in pursuit of this inquiry, looked into some books on chemistry, I perceived the field was boundless. . . . I am determined to study the subject with unwearied attention until I attain some accurate knowledge of chemistry, which is of no less use in the practice of the arts than it is in that of medicine." At this time he was apparently looking at his work more from the point of view of a good draftsman and a hewer of stone. Not for some years was he to devote his attention primarily to the engineering problems confronting him.

A Propitious Era for Engineering Achievement

Perhaps it will be well at this point to glance at the times in which Telford lived. An engineer, perhaps more than other men, is influenced by the age in which he is born. Telford was fortunate to be born in the second half of the eighteenth century, for it was an age peculiarly suited to his gifts. There were as yet no specialists to deprive him of some of his greatest achievements as outside his province. He was born on the very threshold of engineering activity, which had for its first task the improvement of communication systems. The tremendous progress made by motor cars, aeroplanes, telephones, and radio in the first quarter of the twentieth century is scarcely greater than the advance witnessed by Telford. When he was born there was hardly a road in England that did not become a slough in winter and a menace to travelers of all kinds. To go on foot was often the safest and quickest way. By the time he died, however, not only was there a network of good roads and canals traversing the whole country, but railways had become established.

It was an age of economic transformation—a time when new ideas had begun to stir the minds of every thinking man and woman—the period known as the industrial revolution. What gave England the impetus for invention was the fact that she had markets in her colonies for far more goods than she could manufacture, while those same colonies could supply many of the raw materials. James Hargreaves, Richard Arkwright, and Samuel Crompton were responsible for inventions which meant a great deal to the cotton trade—all perfected within the period from 1760 to 1780. Even more inspiring to the young Telford were the improvements on the steam engine, begun by James Watt in 1764. Four years before, when Telford was only three, a new method of smelting iron with coal had been discovered, with the result that the price of iron was reduced. The first iron bridge was built across the

Severn in 1779, and a few years later Telford was to see this structure and himself improve upon it.

The new industries in England demanded a better system of communication, but roads continued to be poor until Telford and Macadam gave the matter their attention. But in this work it must be remembered that Telford and Macadam only followed in the footsteps of the blind John Metcalf, who was a pioneer in the field of good road-making. Telford, indeed, can hardly be regarded as the originator of any new method of communication, although he never failed to improve anything to which he turned his mind. For a long time, canals occupied most of his attention. But here again he was not the first in the field—he had the benefit of Brindley's experience when constructing the Ellesmere Canal. In 1759, Brindley, a man of no education, had built the Bridgewater Canal joining Manchester and Liverpool, and its immediate success in lowering the cost of transportation resulted in a burst of activity to build artificial waterways.

Telford's contribution to the building of bridges was without doubt his most original work. Iron bridges had been built before, but he was the first to see their possibilities at all fully and to attempt their design on a rational basis. As Telford realized that the amount of iron used was not necessarily a criterion of strength, the cost of construction gradually sank lower. In addition, his attempts to span progressively greater distances led him to the use of a suspended roadway in order to avoid the difficulties attendant upon the erection of centering to support a long span arch. The Menai Bridge, which was completed in January 1826, was not the first suspension bridge in England, but it was the first attempt to apply the principle, which had been known for many years, on a large scale.

TELFORD APPOINTED A COUNTY ENGINEER

In 1786, when Telford was twenty-nine, his work at Portsmouth was completed. A year later he was at Shrewsbury, having been invited there by Mr. Pulteney, whom he had met in London. Pulteney wished him to make some alterations to a castle on his estate. This was a purely temporary occupation, but while there Telford was appointed county surveyor for Salop. He remained in this position for six years before he had an opportunity to exercise his powers on an engineering undertaking worthy of his abilities—the construction of the Ellesmere Canal.

The years that Telford spent at Shrewsbury were of immense importance to him and his work. During that time he was responsible for the construction of no less than forty comparatively small bridges with spans of 80 ft or less, and two of considerably greater dimensions. One of these bridges was built across the Severn at Montford, four miles west of Shrewsbury on the road to North Wales. This red-sandstone structure consisted of three elliptical arches, one with a 58-ft span and two with 55-ft spans. It presented no unusual difficulties. The other bridge was to replace a structure at Buildwas that had been carried away by floods. This was of great importance, since Telford decided to construct it of iron and presented a design (Fig. 1) showing some appreciation of the possibilities of the new material. This was only the second bridge to be built of iron, the first cast-iron bridge having been built twenty years earlier, by a Mr. Pritchard, a Shrewsbury architect. Not unnaturally Pritchard had been guided in his drawings by the accepted methods of bridge construction and had produced an arch that differed little in design from that previously used for masonry construction. Telford realized where the mistake had been made and, in his design, showed for the first time in an undertaking of any magnitude his genius for adopting new materials and using them to best advantage.

The Buildwas Bridge had a span of 130 ft. The roadway was carried on a flat circular arch, on either side of which arched ribs sprang from the abutments at points lower than the central arch, and rose at the center well above it. At three sections in the length of the bridge, these three main members were braced together by transverse plates. The total cost of the structure was just over £6,000. Unfortunately, details of the calculations for determining the sizes of members are missing.

THE EPISODE OF ST. CHAD'S CHURCH

Although the story of Telford's first recorded experience as a consulting engineer is well known, it is worth repeating. In 1788 one of the four pillars supporting the tower in the middle of the church of St. Chad's, constructed in the fourteenth century, was found to be cracked. Telford, who was called in, reported that grave-digging close to the foundations of the pillar had caused the latter to sink, endangering the entire structure. He recommended that the bells be removed and the tower demolished in order that the cracked pillar, relieved of its load, might be repaired or replaced. It is said that the consultation began in the church but that Telford, after a cursory glance round, remarked, "Gentlemen, we'll consult together on the outside, if you please."

His recommendations were received very coldly, as being too drastic, and there was not a little suspicion that he had an eye to his own advancement. Accordingly he was ignored and a mason was engaged to patch the damaged pillar. Many consultants in a similar position have no doubt prayed for a just retribution in the shape of catastrophe, but few can have had the dramatic vindication that was Telford's. The work of patching had hardly begun when the sexton, tolling the bell one morning, was startled by a sudden fall of masonry. He left the church hastily. At four the next morning the tower collapsed and the church was damaged beyond repair. It is probable that Telford took advantage of the opportunity to inspect the ruins, discovering as he must have suspected that the walls and pillars were mere shells of masonry filled with rubbish. This was not unusually the case in such ancient buildings, however. Thereafter, Telford always showed meticulous care in the erection of masonry structures, arranging, wherever possible, to leave means of access to all faces of the work, and refraining from filling cavities with earth or carelessly built rubble masonry. The episode probably did far more for his reputation as a

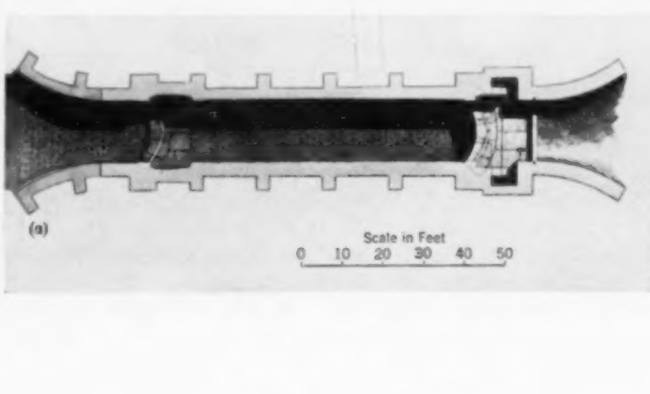


Fig. 3. Typical Lock on the Ellesmere and Chester Canal
(a) Plan of Lock (b) Cross-Section Showing Gate Construction

consultant than many successes in other directions.

During the time that he was county surveyor for Salop, Telford had varied experiences with the roads and bridges in the district, and he was also responsible for the public buildings. The latter responsibility included the erection of a new prison. Throughout this period he was reading and studying a great deal. The chemistry of calcareous substances occupied much of his attention. Telford also made note of many facts in the fields of mechanics, hydrostatics, and pneumatics. The notebook kept at this time, which is still in existence, is most interesting. Its first section contains tables of length, area, and volume giving the relations between French, Russian, and English measures. The second deals with mechanics and contains data for the design of water and wind mills. Another deals with air and water. A table of wind pressures is given. Fortunately for the safety of the structures Telford designed, the values are about 65 per cent in excess of the true pressures. Still another section deals with steam engines. As might be expected, the greater part of the notebook is filled with data on the strength of timber, iron, and masonry. Much of that relating to iron came from Telford's own tests. The accompanying Fig. 2 showing the church of St. Mary Magdalen, which Telford designed and erected at Bridgenorth, gives some idea of his ability as an architect. He himself said of the structure, "The outside is a regular Tuscan elevation; the inside is as regularly Ionic; its only merit is simplicity and uniformity...." The tower surmounting it is Doric.

Among the ambitious projects that occupied Telford's thoughts while he was in Shropshire was one for the rebuilding of London Bridge. For over a century this problem had been under discussion.

In 1796 the Parliamentary Committee on the Port of London considered various schemes for the reconstruction of London Bridge, which was on the verge of falling down, interest centering in designs providing sufficient headroom for ships to pass upstream without lowering their masts. Telford's design, finally adopted practically without change, was for a cast-iron arch made up of five ribs having a span of 600 ft with a rise of 65 ft. Its gradient was to be 1 in 16, and connection with the shore on each side was to be provided by causeways. The causeways were to be supported upon iron arches under which warehouses were to be constructed. A drawing of this bridge was published, and the print apparently was received with great favor. However, the times were considered unpropitious, so the bridge was never built. Telford writes, "I have got into mighty favor with royalty, following which I have received notes written by order of the King, the Prince of Wales, the Duke of York, and the Duke of Kent about the bridge print, and in future the plate is to be dedicated to the King." The bridge, on the other hand, though it was blessed by many engineers, mathematicians, and scientists, was never built.

Considerable interest was felt about this time in the construction of waterways, and in consequence there was no difficulty in finding support for such an ambitious project as the proposed Ellesmere Canal, to connect the Mersey with the Severn Valley and, in conjunction with other canals, Liverpool with Bristol.

TELFORD TAKES CHARGE OF ELLESMERE CANAL PROJECT

Many of the directors of the newly formed company which had undertaken the building of the canal were eminent citizens of Shrewsbury, and during the previous six years they had been impressed by Telford's efficient management of all his works in Shropshire. As a result, in 1793 they invited him to become chief engineer.

Telford did not hesitate to accept this offer, feeling in himself, as he afterwards wrote, "a stronger disposition for executing works of importance and magnitude than the details of house architecture." In addition to the domestic architecture referred to, Telford's work in Shropshire had included the erection of two bridges of considerable dimensions and no less than forty lesser ones. But when the prospect of planning and constructing the 51 locks for the 112-mile canal presented itself, his work in Shropshire no doubt seemed trivial and unenterprising. It is well known that the efficiency of a canal system depends very largely on the watertightness and durability of the lock gates, for, apart from the cost of replacement, repairing and overhauling them obstructs a system of traffic which cannot be diverted. Telford discovered that the alternate wetting and drying of the gates reduced their period of life to only a few years, even when constructed from the best English oak. He decided, therefore, that for the Ellesmere gates he would once again make use of cast iron, a material easily obtainable in Shropshire. Separate castings, 14 ft in width, were made for the top and bottom hinges of some of the largest gates. These hinges were bolted to cast-iron ribs, forming a skeleton which was covered with wood planking (Fig. 3). The cost of replacing the planks as they decayed was low, and the process of replacement presented no difficulties. The skeleton framework of gates for narrower locks, 7 ft wide, was cast in one piece. In this connection it may be noted that Telford made another novel use of cast-iron in the construction of locks at Beeston Castle, Cheshire, shown in Fig. 4. At that point, where the level of the canal was raised through a height of 17 ft, continued difficulty had been experienced in attempting to make the locks water-tight on account of the sandy nature of the soil. In this situation Telford conceived the idea of setting troughs of cast iron for the full width and depth of the canal. The construction of locks by the use of these troughs proved successful.

LOCK VERSUS AQUEDUCT CONSTRUCTION

In laying out the Ellesmere Canal, Telford hoped to avoid the necessity for a large number of locks. In hilly country such as he had to consider here, the difficulties were obvious. The water in the Ellesmere Canal was drawn from Bala Lake and entered the canal at Llandisilio. At two points in the chosen alignment, he had the choice of constructing a series of locks down one hillside and up the

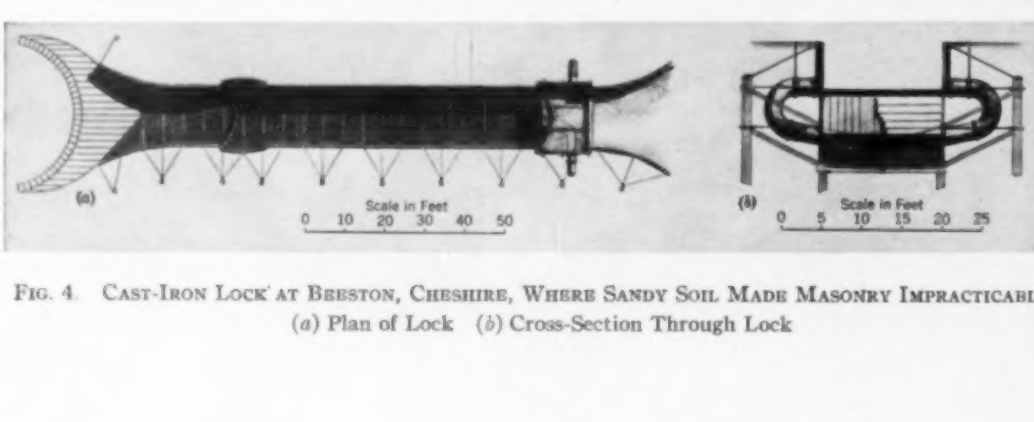


FIG. 4 CAST-IRON LOCK AT BEESTON, CHESHIRE, WHERE SANDY SOIL MADE MASONRY IMPRACTICABLE
(a) Plan of Lock (b) Cross-Section Through Lock

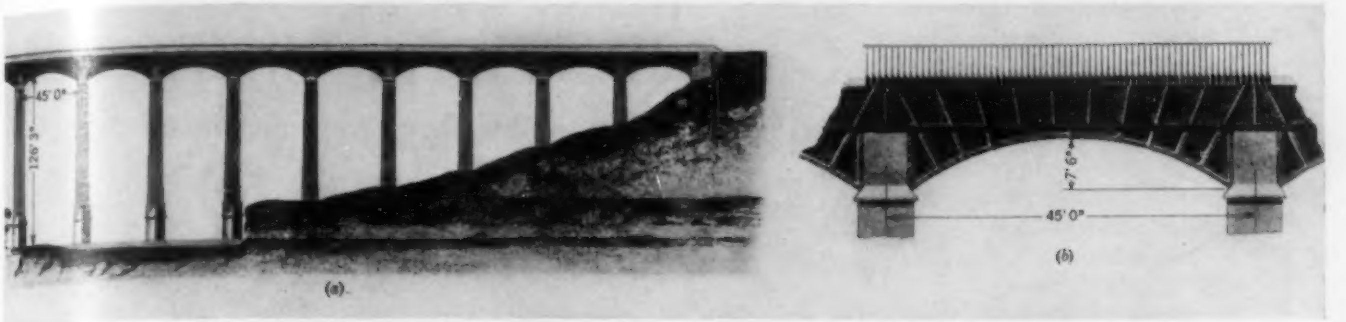


Fig. 5. The Pont-y-Cysylte Aqueduct Carries the Ellesmere Canal Over the River Dee
(*a*) Profile of One Half of the Aqueduct (*b*) Elevation of One of the 19 Cast-Iron Arches

other, or of building an aqueduct across the valley.

In both cases referred to, Telford decided in favor of aqueducts of considerable magnitude. The first of these, near Chirk, crossed the valley of the Ceriog, which is 710 ft wide, at a height of 65 ft. It consisted of ten arches of rubble masonry, each with a span of 40 ft. Considerable difficulty was encountered at that time in constructing a water-tight trough, and the solution usually consisted in providing a wide masonry trough and lining it with puddled earth. The use of this seemingly crude means for retaining water is common even today in the construction of storage reservoirs where earthen dams are built around the area in which water is to be held. In employing this method for an aqueduct, however, the columns and arches would be called upon to sustain not only the weight of the puddle walls and bottom, but also the additional weight of the larger masonry trough made necessary thereby.

Telford saw additional objections to this method of construction. He had observed that great trouble was often experienced from the action of frost in expanding and cracking the puddle, and in some cases causing the collapse of the masonry in the trough. For the Chirk Aqueduct, therefore, he decided to use a novel method of trough construction. Between and parallel to the outer walls of the main structure of the aqueduct, a third wall was built. Across the tops of the three walls cast-iron plates were laid and connected with bolts passing through flanges on their edges. To make the sides of the trough water-tight, they were built up of carefully laid ashlar masonry, backed with brick set in cement mortar. They were then faced with rubble masonry to conform to the rest of the structure. This construction proved entirely successful. The continuous cast-iron bottom not only reduced the weight to be carried by the arches but tied the trough walls together, better enabling them to withstand the pressure of the water.

An even more ambitious undertaking was the other aqueduct—at Pont-y-Cysylte. Here the valley of the Dee, which was to be bridged, was more than 2,400 ft wide and the water level of the canal was 127 ft above the river. The slope of the hill on one side was not too steep to make the cost of an earth embankment prohibitive. Such a fill was extended for a distance of 1,500 ft until its height was 75 ft. This left a distance of 1,005 ft still unbridged. Owing to the limitations of masonry work at that time, it was believed impracticable to attempt to carry the usual form of waterway on masonry piers more than 100 ft in height. Telford had to find yet another new method of construction, and he turned once again to cast-iron. In the Chirk Aqueduct, the use of cast-iron bottom plates had, by eliminating the puddle lining, brought about a great saving in the weight in the trough. Today, it seems natural enough that, in considering how a further saving of weight might be effected, Telford should think of extending the use of iron to the whole trough. At the time, however, such an idea marked a distinct advance over existing methods, and Telford deemed it desirable to check his design with a model complete in every detail. The model proved satisfactory, and work was begun on the aqueduct.

Extending the Field for Iron

It is interesting to note how Telford's confidence in the use of iron had grown. In the construction of the Beeston Castle lock it had enabled him to build successfully in a bed of sand. In another part of the canal he had already carried the whole of the waterway in a cast-iron trough for a short distance. But in the Chirk Aqueduct he was to carry the canal and towing path in one iron trough for a distance of 1,005 ft at a height of 127 ft.

Twenty piers, the highest rising to a height of 121 ft, were built of local sandstone. The cross-section of each was 20 by 12 ft at the bottom, tapering to 13 ft by 7 ft 6 in. at the top. The first 70 ft of the pier was built solid, but the final 50 ft was hollow, with outer walls 2 ft thick and one inner bracing wall. Telford made a great point of building masonry structures in this way, so that all sides of the structure could be inspected. He also felt this method ensured the best workmanship and made it possible to have complete confidence in the bearing power of the whole cross-section. It was not only in the construction of masonry piers that Telford avoided filling. As has been shown, he built a third inner longitudinal wall for the Chirk Aqueduct and followed the same plan in the construction of masonry bridges. In the past it had been more usual to fill the spaces between arches and outside walls with earth or rubble.

Across the top of the piers Telford now placed the cast-iron trough, bolted together and stiffened by iron ribs on the under side, as shown in Fig. 5. The span between the piers measured approximately 54 ft, and the inside width of the trough was 11 ft 10 in. The towpath was placed at one side within the trough. It was carried on columns standing in the waterway so that, although it reduced the width of the canal available for barges, it provided a free area of water, thus preventing the piling up of water in front of the moving barges. It is this piling of water which makes towing arduous in a narrow channel. The same plan of carrying the towpath on columns standing in the waterway and thus saving the overall width necessary, was followed in two short tunnels—one 1,500 ft long and the other 600 ft long—excavated on this canal system.

Telford does not appear to have encountered any serious obstacles in constructing the Ellesmere Canal. There is no record of any difficulty in obtaining castings, and the fact that no faults are reported speaks well for the Shropshire iron founders, upon whom he was later to depend in designing still more ambitious structures.

Correlating Ground and Air Surveys

How Maps Are Made from Aerial Photographs by Use of Stereoscope and Ground Controls

By Arthur W. Lambert, Jr.
Aerial Survey Section, U. S. Engineer Office, St. Louis, Mo.

Give us wings, O Lord, strong wings,
And let us mount into the sky;
That we may view the earth about us
As it really is—glimpsed, as it were,
By some celestial eye!

Until about three decades ago, says Mr. Lambert, similar more or less poetic thoughts were very common, illustrating that to the average layman a map is merely a simplified bird's-eye view of a given area. But bird's-eye views, though common enough today in the form of aerial photographs, are not maps. Rather they are perspectives, or orthoscopic projections of surface points, subject to errors of horizontal displacement due to varying distances from the photograph center, differences in elevation, and many other lesser factors. After distinguishing between the two, Mr. Lambert describes in some detail the art of photogrammetry or the making of maps from aerial photographs. The article concludes with an evaluation of air and ground surveys, pointing out that best results are achieved when the two are used in effective combination.

Today we have wings such as no bird ever dreamed of, and can see the world as it "really is," or rather, as it really appears from practically any height that we desire. And what is more, by the use of modern photographic equipment we can preserve any particular view-impression we may care to retain for future consideration, measurement, or scrutiny. Such an aerial picture can provide a most interesting and useful fund of detailed information; but it is not a map.

In differentiating between an air-photograph and a map, I do not refer to the incomparable wealth of detail of the former, nor to the fact that the ordinary single exposure covers only a comparatively small area, but to a very important fundamental difference. The term "air-photograph" is usually used to mean an ordinary single exposure made from an airplane with a mapping camera in proper adjustment and truly vertical at the instant of exposure.

Let us cover an air-photograph with transparent cloth or paper, and draw in the roads, streams, fences, land lines, and other outlining features. And let us indicate in the conventional manner houses, hills, trees, culverts, bridges, ravines, and other topographical features that we desire to record. We now have an outline portrayal of the area in question. It looks like a map, and it can be used in most respects as a map—but it is not a map. When referring to maps, we mean maps in a technical sense, correct from a mathematical standpoint.

The fundamental difference between a map and a photograph lies in the fact that the two are produced by entirely different systems of projection. A map is a plan, or orthographic projection, whereas a photograph is a perspective, or orthoscopic projection, and typographically speaking, photogrammetry is the art of making maps from air-photographs.

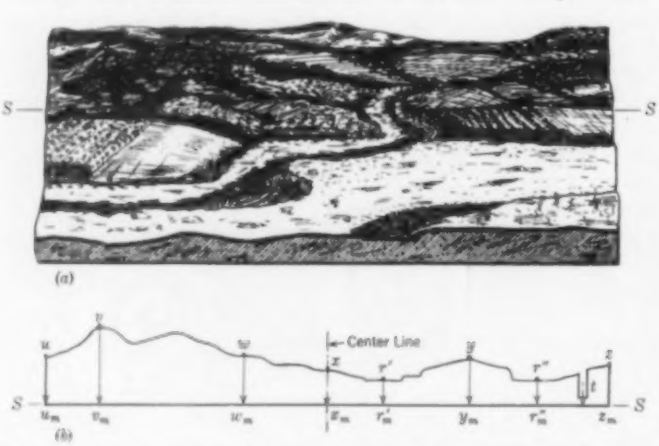


Fig. 1. A 1:1 Plan Drawing of a True-to-Scale Model, if Available, Would Constitute a Map

(*a*) Model of a Portion of the Earth's Surface

(*b*) Sectional Elevation on the Line *S-S*

Turning Photographs into Maps

One very convenient way to make a map is to take a true-to-scale model of a portion of the earth's surface, and make a 1:1 plan drawing of it. With a surface gage we can accurately measure comparative elevations for drawing in the contours.

A true-to-scale model is shown in Fig. 1(*a*). The under side, *S-S*, in this model represents sea level. If we consider the area with which we are concerned small enough to neglect the curvature of the earth, then all that is necessary to produce an accurate map of the area to the same horizontal or planimetric scale as the model, is to project each object point on the surface of the model vertically downward.

As shown in Fig. 1(*b*), a section taken through the model on the line *S-S*, the vertical projections of the surface points on the datum plane are the respective "plumb points," u_m, v_m, etc. These so-called plumb points mark the true map positions of the objects on the surface, regardless of their elevations. Nor does it make any difference where we locate the datum plane. So long as it is a horizontal plane, the relative horizontal displacements of the map locations of all points thus projected remain the same.

In Fig. 2 is shown a perspective or orthoscopic projection of the same points illustrated in the previous diagram, with the apex or orthoscopic point at *L*. If *L* is the camera lens, all rays that pass through it are brought to a focus on a negative plate or film. If a contact print is then made of this negative we obtain the positive representation or picture, *P*, which is exactly the same as the negative except that it is reversed. This positive picture will be identical with an orthoscopic projection made as indicated by the converging rays in Fig. 2. Thus, by placing the eye in the same relative position with respect to the picture as was the camera lens to the negative plate, we obtain a congruent image effect identical with the projection illustrated.

In the diagrams, the simple letters, *u*, *v*, *w*, etc., represent natural object points on the surface of the ground. The same letters with the subscript *m* refer to the vertical or orthographic projections of the natural object points; with the subscript *o*, they refer to orthoscopic projections on the datum plane, and with the subscript *p*, to orthoscopic intersections with the picture plane *P*.

Referring to Fig. 2, we see that for only one of these points are the *m* and the *o* projections coincident—the center-line point *x*. This is the nadir point of the camera axis. On the *S-S* plane, all *o* projections are seen to fall beyond the *m* projections.

With very few exceptions, points on the earth's surface are at greater elevations than sea level. Thus if we refer to mean sea level as the datum plane, the respective projections of surface points will fall outside their respective vertical projections or true geographic locations, for any vertical section of the terrain beneath the camera in which the camera axis, or plumb-line, is an element, as shown in Fig. 2.

It should be noted, however, that these outward displacements are not only proportional to the relative elevations but also to the radial distances of the points in question from the plumb point. Thus, although the two points *u* and *w* are at approximately the same elevations, the outward radial displacement, $u_m - u_o$, of point *u* is much greater than $w_m - w_o$, that for point *w*.

U. S. Army Air Corps

THESE ARE NOT MEN FROM MARS, BUT PILOT AND AIR-PHOTOGRAPHER READY FOR A HIGH-ALTITUDE MISSION

From similar-triangle relationships it is clear that the *p* projections on the picture plane *P* are directly proportional to the *o* projections on the datum plane *S-S*. Consequently on the picture plane *P* we have a small true-to-scale representation of the orthoscopic, or perspective, aspects of the ground surface in question. On the picture plane, therefore, the images of the respective elevated ground points will not be at their true map positions, but will have the same relative outward displacement from the center of the picture as the points themselves had from the plumb point on the datum plane.

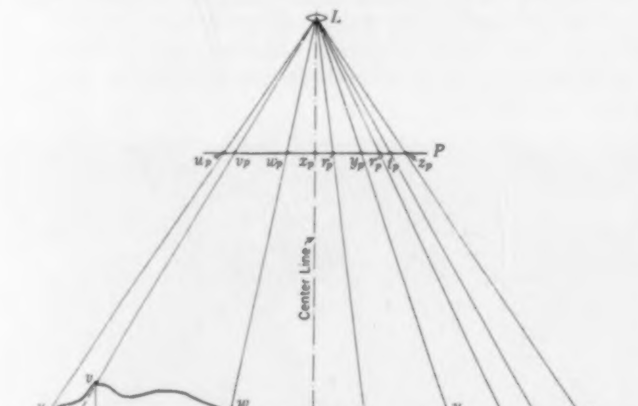


FIG. 2. ORTHOSCOPIC PROJECTION OF SURFACE POINTS AS SEEN THROUGH CAMERA LENS *L*

P Represents the Picture Plane; *R-R*, a High-Level Datum Plane; *S-S*, Datum Plane at Sea Level

If we take our datum plane at a different level, such as the lower river-level *r′* shown in Fig. 2, the displacements of the *o* projections will be changed. Since the new datum plane *R-R* is parallel to the previous datum plane *S-S*, these offsets are in direct proportion to the previous values, and are still in a direct proportional relationship to the offsets on the photograph. However, a change in the relative positions of the *o* projections and the map locations may occur with respect to the center line. For example, since the point *t* (which we will assume is visible from *L*), is below the given datum plane, its orthoscopic or perspective projection will be closer to the center than its true map location, and its image on the photograph, t_p, will be closer to x_p than will its smaller-scale "map position."

If we take the datum plane at a higher level still, say at the point *y*, about half the *o* projections, and consequently the smaller-scale *p* projections, will be closer to their respective map locations and the other half farther away.

The whole process of making accurate planimetric maps from photographs thus hinges on the art of recognizing the various displacements of the photographic images and applying the proper correction. But for this troublesome necessity, making accurate maps from air-photographs would merely require enlarging or reducing the original photograph to the required scale.

In very flat country, maps and photographs made to the same scale are very nearly congruent, particularly when made from points of great elevation. But, for the average terrain, all points on the earth's surface must be presumed to be at different elevations until proved otherwise. In some mountainous sections, the differences in elevation between given pairs of ground points may even exceed their horizontal, or map, distances.

In precise surveys that cover large areas, the earth's curvature must be taken into consideration. The same is true of comparable air-surveys. Also, other corrections must often be made before the actual photographs that are handed to the cartographer can be assumed to be fit to work with. These, however, are more or less complicated technical details that can only be mentioned in passing.

To cover large areas it is necessary to take many photographs and combine the aggregate data. The marvelous multi-lens cameras of modern air-photography, such as the three-, four-, and five-lens cameras developed by Maj. J. W. Bagley, U.S.A., and the new nine-lens camera designed by O. S. Reading of the U. S. Coast and Geodetic Survey, combine groups of simultaneous exposures made in different directions optically. The resulting mosaic becomes in effect a single vertical picture covering a very large area, instead of the patchwork mosaic made up of a number of different exposures, matched as nearly as possible and pasted on a board.

A STEREOSCOPIC MODEL OF THE TERRAIN

In an earlier paragraph we casually referred to making a map from a true-to-scale model. The veteran plane-table man or transitman, with recollections of set-ups in the middle of swamps or on the near-vertical slopes of a rocky mountainside, will agree that such a procedure would be a welcome innovation, if someone would only supply the model. Yet this is just what can be done today!

The technical operations necessary to readjust the photographic point locations before they can be plotted as true map locations are, as we have inferred previously, the bane of the planimetric map-maker. But the very factors that prove so troublesome, namely the disproportionate offsets from the center of the photographic plate, make it possible to bring just such a model as is pictured in Fig. 1(*a*) into the photogrammetrist's laboratory for measurement or observation. Instead of being a plaster cast, it is an optical model. But, phantom though it may be, it is just as effective as if it actually existed, is a very close approximation of a rigorously true-to-scale representation, and can be measured and contoured in the laboratory to the heart's content.

Official Photo, U. S. Army Air Corps

FLIERS WHO MADE AERIAL MAP OF EAST AND SOUTH COAST LINE OF FLORIDA, SHOWN WITH T-2 (FOUR-LENS) CAMERA

Stereoscopic viewing apparatus enables the cartographer to be "present" on the terrain he is mapping, even though he may actually be hundreds of miles away, and modern stereoscopic plotting methods enable the experienced aerial surveyor to produce an entire topographic map, contours and all, direct from the photographs of the covered area.

Stereoscopic reconstruction is the process by which the small-scale optical models are produced in the photogrammetric laboratory. When we view any natural scene with our two normal eyes, we actually receive a different image impression on the retina of each eye. The right and left eyes of the observer, being separated by a distance of approximately $2^1/_2$ in., act as separate miniature cameras photographing the same view.

The two separate retinal images, however, are both transmitted by the optic-nerve system to the same brain, where, because the two "pictures" are slightly different, they cannot be made to register perfectly throughout. This lack of perfect register is interpreted as depth. Thus, we see natural objects or scenes in a three-dimensional aspect.

In taking aerial photographs for map-making purposes, the exposures are made in strips, and the camera is so timed that there is an overlap of approximately 60 per cent between successive pictures. Thus, every point on the ground appears in at least two successive photographs. Since the camera was at different air stations for each two successive exposures, the resulting pictures are photographs of the same area that are nearly, but not exactly, alike.

These views are termed "stereoscopic pairs," and if they are placed in the proper relative positions and observed simultaneously, so that the right eye sees only the right-hand picture and the left eye sees only the left-hand picture, the slightly out-of-register pair of pictures is transmitted to the brain as if the two eyes were actually seeing the area photographed, with the right eye at one air station and the left eye at the other.

To adapt the eyes to the task of viewing a stereoscopic pair of photographs, stereoscopes are used. The small parlor variety of this instrument is too well known for further comment. If the stereoscopic pairs of photographs are free from distortions and properly mounted in the viewing instrument, there appears an optical illusion which is an exact counterpart of the original scene. It is this that the map-maker examines.

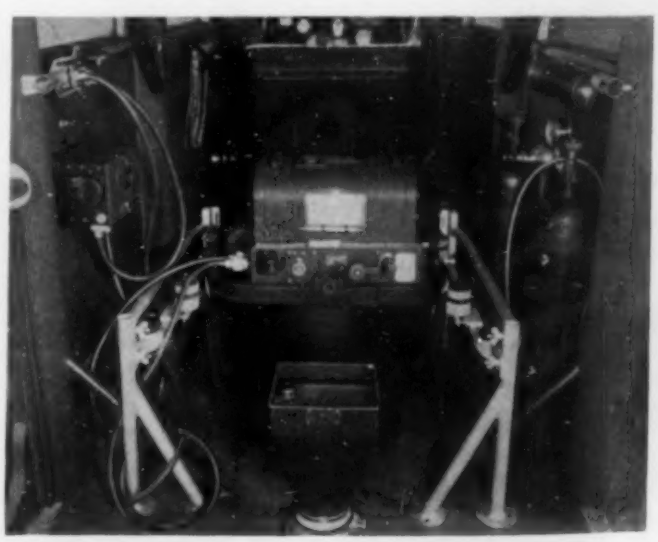
In examining a stereoscopically reconstructed model of a part of the earth's surface, the two eyes can be likened to a pair of small, independently mounted telescopes set up at the two ends of a fixed base-line position. With suitable devices for measuring and recording the angles of convergence and other constants from this fixed aerial base to any point on the model, it is possible to fix the relative map positions of points as well as their relative elevations with regard to any given datum plane, such as *S-S* in Fig. 1.

The principles of stereoscopic reconstruction are comparatively simple, but the mechanical and optical difficulties incidental to the design and construction of satisfactory machines for accurate stereo-mapping and contouring are exceedingly difficult to overcome. The most accurate machine so far built for this work is, perhaps, the stereoplanigraph pictured in one of the photographs.

From this necessarily brief description of certain phases of the art of making maps from air-photographs by photogrammetric manipulations, it must not be inferred that the process is delightfully simple and nearly automatic. In fact, many of the necessary steps are exceedingly difficult to perform satisfactorily, and the constantly increasing accuracy and flexibility of air-surveying methods is a tribute to the genius and skill of mechanical and optical technicians who are primarily responsible for the developments of photogrammetry.

RELATIONSHIP BETWEEN OLD AND NEW METHODS

The underlying principles that apply to the making of maps from air-photographs are not new. Except, perhaps, for some of the comparatively recent adaptations based on stereoscopic reconstruction and analysis, little is novel in photogrammetric theory. The chief contributions of the past two or three decades lie in the steady and progressive development of specialized air-photographic equipment and the contemporary development of the modern high-flying airplane. It is a long way from the top of a tripod to a point between 16,000 and 25,000 ft above the ground.



Official Photo, U. S. Army Air Corps

INSTALLATION OF K-3 (SINGLE-LENS) CAMERA AND EQUIPMENT IN CABIN PLANE

In view of the rapid development of air-surveying methods, it is natural that those who learned much of the practices of ground-survey methods, or who are at present worshiping at the shrine of this or that author of surveying texts, should speculate on the possibilities of technological development. Of what use will be the principles and practices that are in process of absorption at the present moment? How much will be obsolete in the next few years? To what extent will the methods of air-surveying supplant those of ground surveying?

We might answer this question by propounding another. To what extent has the modern calculating machine supplanted paper and pencils? There is little danger that time spent in studying the old methods will prove time lost. The aerial surveyor will not supplant the ground surveyor. On the contrary, aerial work is destined to greatly enlarge the scope of the ground surveyor and make his task more interesting. Aerial surveying methods do not eliminate, but supplement the transitman and levelman. Indeed, for best results the photogrammetrist depends on the best ground assistance.

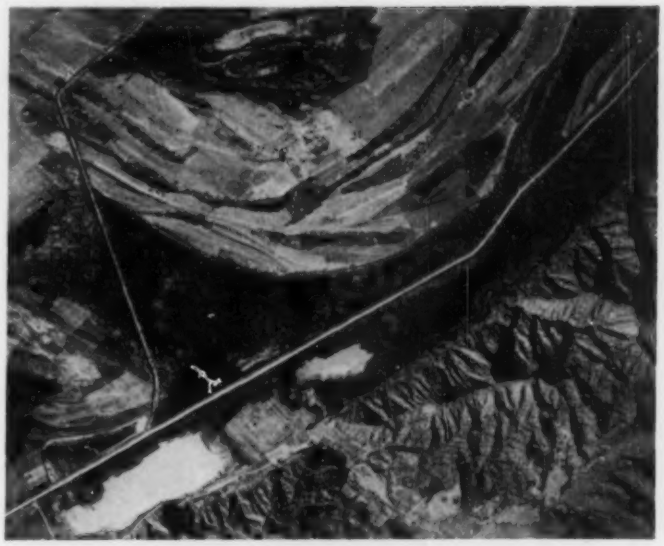
One thing that air-surveying will do, however, will be to eliminate a great deal of the "trudgery," thus enabling ground parties to spend more time carefully locating important reference points, such as first-, second-, and third-order triangulation stations, and less time in obtaining and recording data of minor importance.

To a great extent the relative use of ground and air-survey methods depends on the character of each individual project. In all mapping work we must be content with results in which the acceptable tolerance is within the limits of the expectancy of acceptable error, and as cost is usually an important factor, we must consider the purposes for which any particular project is intended and cut the cloth accordingly. The tolerances of ground surveying are too well known to require further consideration here. Likewise air surveying is afflicted with the curse of inherent and residual errors.

In dealing with photographic plates or prints, upon which we must depend for the great majority of our measurements, we are dealing with very small quantities, minute in fact, in which thousandths and even ten-thousandths of an inch play important rôles in determining final results. Because of this influence there is a more or less definite plus-or-minus error that must be dealt with.

Fairchild Aerial Surveys, Inc.

Air Surveys Are Particularly Adapted for Mapping High-Relief, Mountainous Country Such as This



Alluvial Plain Flanked by High Ground with Relief
Terrain Such as Shown Here Is Easily Accessible to Ground as Well as Air Parties

The government is buying vast quantities of marginal and submarginal land in connection with various projects, and most of this land can be and is measured and plotted by photographic methods. Where land is valued at a few dollars an acre, extreme accuracy in mapping, so far as land acquisition is concerned, is not essential. If a farm that must be acquired before a dam can be built is worth from $75 to $100 an acre, what difference if the planimeter scales a few square yards over or under the actual acreage involved? In such cases the total cost of making an extremely careful and accurate survey from a scientific standpoint is far greater than any small difference in adjustment cost resulting from such error, so that usually a satisfactory figure can be mutually agreed on from an ordinary photographic survey.

In laying off or locating property lines in connection with urban property or city lots, particularly in sections where ground is considered "real estate" with a front-foot or even a square-foot value, it is probable that the aerial survey will never function as we might like it to do. For many years to come, we will probably continue to depend on the most careful measurements possible with tapes, levels, and transits.

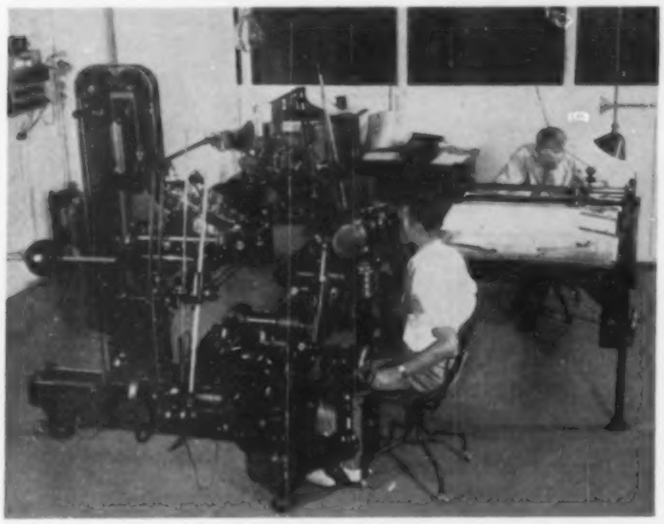
Similarly, in running drains, grades, or gradients for sewers and the like, only most careful leveling on the ground itself will give results of the necessary accuracy. The ground surveyor will also continue to be of great assistance in fixing important elevations, as well as spot-elevations for determining contour lines at one- or two-foot intervals in comparatively flat country.

GROUND CONTROL IS NECESSARY

The true function of the ground surveyor in modern mapping work may be likened to that of the structural engineer and erector in modern building operations. Unless every member of a steel skeleton framework is properly assembled, the floors will be tilted or warped and the walls out of plumb. Similarly, in attempting to produce an accurate map by photographic survey methods, unless the skeleton, or as it is technically known, the control, is accurate and adequate, the fill-in information will not be in true geographic or geodetic relationship, no matter how carefully the secondary measurements may be made, or how neatly the drafting is done.

One function of the air-photograph is to supplant the

voluminous field notes that must later be translated and transcribed into the details of the finished map or chart. Where field notes are apt to be skimpy, somewhat unintelligible, or otherwise faulty, the air-photograph is a complete inventory of all visible topographical features. This makes the task of detailing much simpler and far less likely to contain interior errors or omissions that would be the case with "cold" descriptions in longhand.



Fairchild Aerial Surveys, Inc.

STEREOSCOPIC TYPE OF PLOTTING MACHINE FOR PRODUCING SMALL-SCALE MODELS OF AREAS PHOTOGRAPHED

By Turning Two Hand Wheels and One Foot Wheel the Operator Virtually Measures the Phantom Model. The Motion of the Pointer Is Transmitted to the Assistant's Table, Where the Pencil of the Coordinatograph Draws the Map

For most economical results, the correlation between the ground work and the photogrammetric work in any given survey should be properly proportioned. Excessive ground work is unduly expensive, as is excessive reliance on the photogrammetric analysis.

For every job, the right ratio lies somewhere between the two extremes, and in a well-balanced survey a proper planning of all new work should endeavor to properly correlate the ground and air departments.

By the use of equipment now available, a topographic map covering an area of several hundred square miles, complete with relative geographic and geodetic relationships between all important points, located to a degree of accuracy suitable for any but the most exacting requirements, could be made without setting foot on the ground.

Such a map, however, would be of an area floating in space as it were, and without accurate scale. To give this map an accurate scale and a proper terrestrial location, it would be necessary to know the positions of at least two points. Then the area could be definitely oriented with respect to the earth's surface.

But what of the cost? A few of the operations that would ultimately be reflected in the final bill will be listed. We would have to take into account, and make minute corrections to compensate for, all knowable errors attributable to distortions in the lens, films, prints, or other reproductions from which the map was made. We would also have to make corrections for very small errors due to mechanical and optical defects or shortcomings in the apparatus used for measuring the final photographs, or inherent in the machines used for plotting. And we would have to know and be able to eliminate errors due to the personal equation of the operators responsible for the various stages of the work.

An immense number of accurate measurements and a great many intricate calculations would be required to avoid accumulation of error as the survey was extended from its starting point. All this would take time. Furthermore, such operations could only be made by men of the highest technical skill and mathematical abilities. The bill for salaries would reach stratospheric levels. Thus, while the undertaking is possible, it is impracticable from an expense viewpoint, both as to time and money. Half a dozen well located triangulation stations, properly distributed over such an area, would furnish convenient checks that would eliminate a very great proportion of such labor and expense.

The air photograph serves two important economic functions relative to mapping activities. It makes possible, at a comparatively low cost, the mapping of large inaccessible or economically inaccessible areas, particularly of low-value lands, providing at the same time complete ground inventories and often much valuable prospecting data. It also makes it possible to centralize the actual cartographic work of the topographical staff at any convenient permanent location, even thousands of miles from the area being surveyed.

Official Photo, U. S. Army Air Corps

THESE MOSAICS WERE MADE BY FITTING TOGETHER MANY SMALL SINGLE-LENS PHOTOGRAPHS

Photographing an area is usually a matter of only a few hours of actual flying time. However, certain seasonal and atmospheric conditions must be taken into consideration, so that the actual time spent in covering an area to be surveyed must allow for delays. But once the photographs are taken, the work of mapping can be carried on at leisure. Thus this phase of the work may be distributed over the entire year, regardless of season or weather.

Only the important spots have been touched in this discussion of a comparatively new and fascinating subject. As usual, the pioneers have made progress slowly in the face of opposition. In the United States we are still years behind many foreign countries in appreciation of these aids to surveying and mapping, and we are woefully behind in the domestic production of adequate photogrammetric machines and appliances. But as an aftermath of the depression, the necessity for providing adequate surveys and maps for various governmental projects has given impetus to the work, and it is probable that within a few years we will at least catch up with our contemporaries across the sea.

Models Guide Work on Western Dams

Found Indispensable in Design and Construction of Dams at Grand Coulee and Fort Peck

INCREASING recognition is being given to the value of hydraulic models as an aid in analyzing some of the knotty problems involved in the design and construction of large dams. Tests on models frequently reveal factors which have an important bearing on the operation of their prototypes, and also provide quantitative checks on design assumptions. The following two articles have been developed from presentations of this subject at the Society's Portland Convention, July 16, 1936.

In the case of the Grand Coulee Dam, Mr. Warnock tells how model testing indicated a method of protection against scour at the toe of the overflow spillway and provided valuable information on transverse wave and pool action; erosion of river bed; design of spillway training walls, crest, and drum gate; and diversion problems which were anticipated during construction.

The second article, by Mr. Hathaway, describes similar studies on models of various parts of the Fort Peck Dam. Objectives of tests on the spillway model were the most efficient hydraulic design and the most efficient means of preventing scour. Tests on a model of one of the tunnel and control structures gave important information on flow conditions and head losses. Flow conditions at the tunnel outlet works and suitability of the soil at the dam site were also studied.

Experiments Aid in Design at Grand Coulee

By Jacob E. Warnock
Associate Member American Society of Civil Engineers
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BY the time the design and construction of the Grand Coulee Dam had been assigned to the Bureau of Reclamation, the practice of using hydraulic models as an aid in the design of large hydraulic structures was well established. Models were first used extensively by the Bureau in 1930 in the design of the spillway for the Cle Elum Dam of the Yakima project in Washington. The design of the spillways for Boulder Dam, Madden Dam in the Panama Canal Zone, and Norris and Wheeler dams for the Tennessee Valley Authority, served as stepping-stones in further developing the technique and improving the methods.

The major problem in connection with the design of the proposed overfall spillway for the ultimate development of the Grand Coulee Dam was that of protection against scour at the toe. With a designed capacity of one million cubic feet per second and a difference in head of 280 ft, the energy to be dissipated will be 31,800,000 hp, or 19,300 hp per ft of gross spillway crest length. Four different models were tested in an attempt to develop a method of protection that would satisfy this unprecedented requirement. Each was constructed with definite limitations and for a definite purpose. The first model was built to a scale of 1:184 and was tested in the hydraulic laboratory of the Colorado Agricultural Experiment Station at Fort Collins, Colo. Extensive experiments were then in progress in that laboratory on similar problems for the Norris and Wheeler dams, so that very little space was available for models of the Grand Coulee Dam. Furthermore, no funds had been appropriated for the design of the ultimate development of the Grand Coulee Dam, even though it was proposed that certain of its features would be included in the initial stage of construction.

The small scale of the model may throw some doubt upon the accuracy of the quantitative results. However, this model did serve admirably in a qualitative way for the study of suggested designs and for the elimination of undesirable ones quickly and economically. An analysis of the data secured from the model indicated that the topography of the site, the tailwater-discharge relationship, and the condition of the river bed were such as to dictate the use of an apron, or bucket, curved in section and placed at a very low elevation.

A further refinement of this design resulted in the addition of a dentated lip on the downstream edge of the bucket, which produced excellent results. The modified design eliminated both the impingement of the jet directly on the river bed and the scouring effect of the turbulent flow. However, the behavior of the water in and around the teeth of the dentated lip led to the belief that partial vacuums existed. That condition would be serious because of the possibility of cavitation and consequent destruction of the teeth.

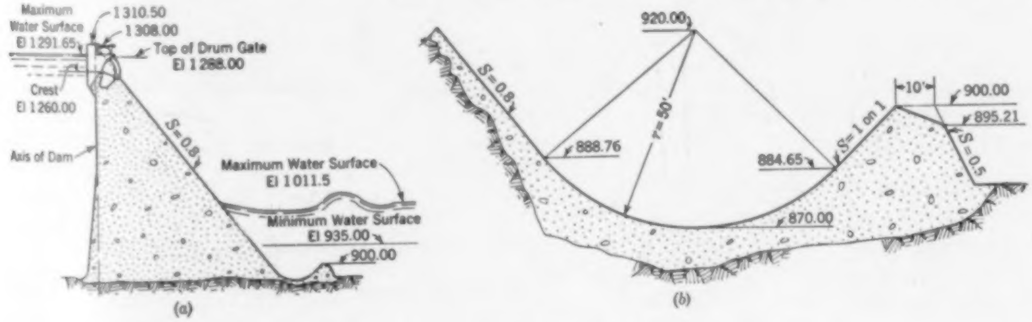
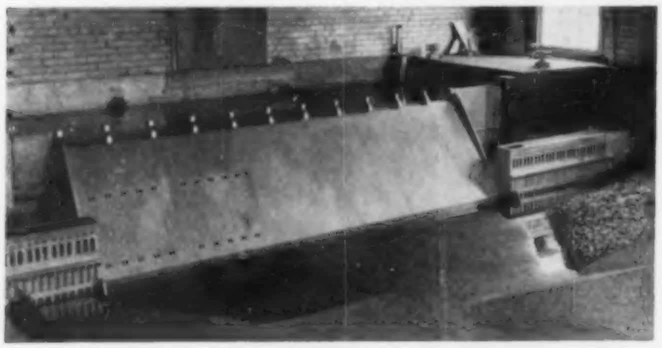


Fig. 1. Section through Spillway of Dam
(*a*) Showing Position of Bucket (*b*) Showing Final Design of Bucket

LARGER MODEL BUILT FOR STUDY OF BUCKET

Since the 1:184 model was too small to allow detailed studies of these

pressure conditions, a second model was constructed to a scale of 1:40 (Fig. 1). This model consisted of one gate with half of a pier on each end, and the downstream face of the spillway, including the bucket at the toe. A glass panel, 6 ft long by $3^1/_2$ ft high, was built into one side of the flume to permit study of the



The Model of the Complete Ultimate Development, Built to a Scale of 1:120

flow conditions in the bucket. Piezometers were installed in the faces of two teeth to measure pressures.

The glass panel was invaluable in that it made possible a visual concept of the action in the bucket. Regardless of the amount of data which may be obtained by other devices, none has proved as effective as this in affording a mental image of the true behavior of the water. When pressure studies substantiated the belief that partial vacuums did exist around the teeth of the lip, extensive efforts were made either to reduce or to eliminate them.

Since very little was known concerning the effect of the dissimilarity between the vacuum conditions in model and prototype, it was believed advisable to construct a third and larger model. Accordingly, a model to a scale ratio of 1:15 was constructed and studied at the Bureau's laboratory on the south canal of the Uncompahgre irrigation project near Montrose, Colo.

From this point until completion of the experiments for final design, the testing on the two large models was carried on simultaneously, permitting direct comparison of data. Every effort was made to find a modification of the dentated lip which would not have the objectionable vacuum condition, but it was not found possible to avoid the vacuum without impairing the effectiveness of the lip. An incidental test was made to determine the extent of the battering effect of ice or other materials which might be carried into the bucket during the operation of the spillway gates. By the use of cakes of paraffin and short lengths of weighted dowel rods to simulate ice and water-soaked logs, it was disclosed that the sharp edges of the teeth would be rapidly abraded. As a result of the foregoing observations, the dentated lip was eliminated. The design of the bucket as finally adopted is shown in Fig. 1.

Testing Pressures and Velocities in Bucket

After the design of the bucket had been fixed, an additional program of testing was undertaken to obtain more detailed information concerning the pressures and velocities in the bucket and the extent of scour in the river bed. Piezometers were installed in the bucket and on the faces of the lip at such intervals that there was no possibility of a change of pressure occurring unobserved. Pitot-tube traverses were made at representative sections.

The pressure measurements served to supply data for the structural design of the downstream part of the bucket and to relieve the concern expressed regarding the possibility of the formation of negative pressures directly downstream from the crest of the bucket lip. The pressure data obtained are illustrated in Fig. 2. As may be seen, the anticipated negative pressures did not appear.

A very clear picture of the behavior of the internal mechanism by means of which the roller accomplishes the dissipation of energy was obtained from the velocity traverses. The descending sheet of water plunged into the tailwater and diverged. This divergence can best be described as a process of raveling due to contact with the roller. After the stream enters the bucket, it is diverted with a practically constant velocity to the crest of the lip at El. 900.0. The effect of the lip is to divide the jet into two parts, of which one is deflected upwards to form the elliptical surface roller with its major axis in a horizontal plane above the bucket, and the other bends downstream and forms the so-called "ground roller."

These two rollers are the fundamental factors which govern the dissipation of energy and the prevention of scour. The upstream surface roller is primarily effective in dissipating the energy which might otherwise prove destructive to the river bed, while the direction and intensity of the ground roller determine the extent of the erosion immediately below the bucket. It was found that a slope steeper than 1:1 on the upstream face of the lip produced a too nearly vertical deflection of the jet, with the result that the ground roller dipped sharply and produced excessive scour, and the surface roller was rendered ineffective. For slopes flatter than 1:1, the surface roller tended to "sweep" out of the bucket and the ground roller was obliterated by a downstream current which again produced excessive scour.

A significant fact brought out by the pitot-tube traverses was that the actual maximum velocities in the curved part of the bucket are materially less than might be expected from theoretical considerations. For

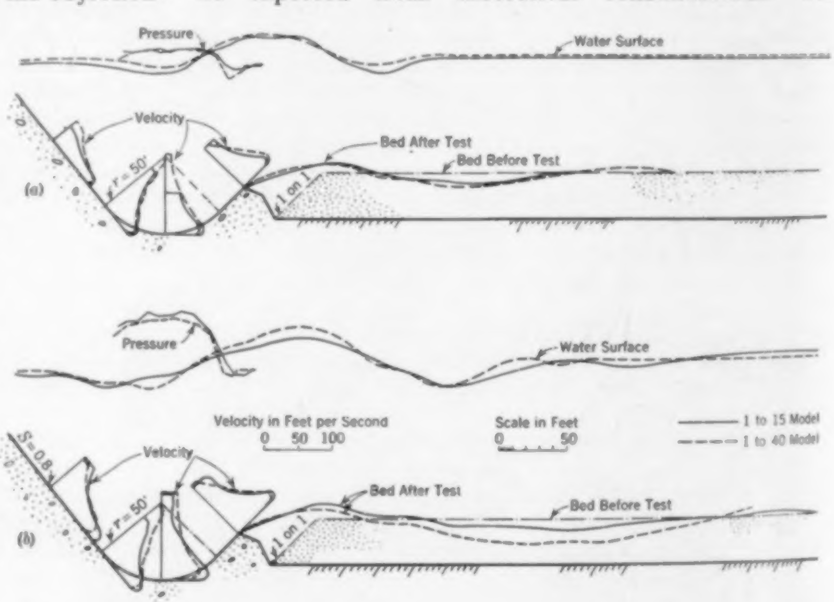


Fig. 2. Comparing Flow Characteristics in Models of Final Bucket Design
(a) Discharge 500,000 Cu Ft per Sec (b) Discharge 1,000,000 Cu Ft per Sec

example, it was found that with a spillway discharge of 500,000 cu ft per sec, the maximum velocity measured at the point where the descending sheet enters the pool was 133.0 ft per sec. This was found to be in excellent agreement with the calculated velocity of 141.0 ft per sec. At the point of tangency the maximum measured velocity was 55.0 ft per sec.

In making observations on the erosion of the bed below the bucket, care was exercised before each run to restore the surface of the bed to a predetermined profile selected to facilitate comparison. From the downstream toe of the bucket, the bed material was carried up on a 1:1 slope to simulate the condition that will probably exit following construction. It was found that, as the discharge gradually was raised to capacity, the river bed material was carried back against the bucket, completely filling the trench and forming a deposit parallel to the lip and roughly parabolic in section. This deposit proved to be quite stable and was not materially affected by subsequent variations in the discharge.

Model buckets with radii of 30, 50, 75, and 100 ft were tested during the course of these studies. The circular roller of the 30-ft bucket was much less effective than the elliptical roller of the 50-ft bucket. The use of a 75 or 100-ft radius resulted in only slight further improvement, which was insufficient to justify the additional cost.

Studies to Eliminate Transverse Waves

During the test on the 1:184 model, a curious transverse-wave phenomenon was observed. Starting with a swell which formed midway between the side walls, the wave divided, traveled laterally to the sides, and was reflected back to the center. This action was repeated continuously. As indicated in this model, the wave, if reproduced in corresponding degree in the prototype, would seriously batter the spillway training walls and the ends of the power houses. It was thought at first that this phenomenon might have been due to the fact that the 1:184 model reproduced only a part of the spillway. Experiments with dentated sills demonstrated that the wave could be eliminated by this means, but as has been previously mentioned, other considerations led to the rejection of that solution.

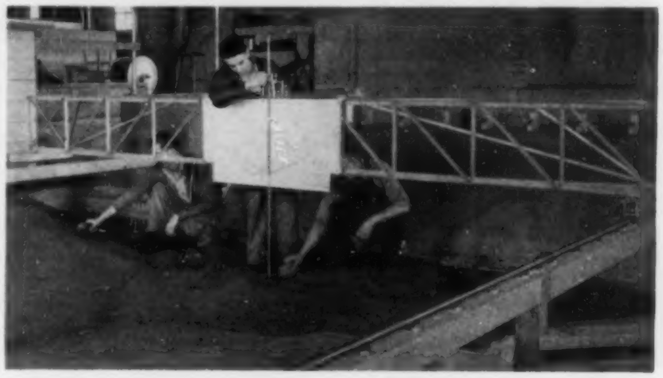
The same phenomenon was observed on both the 1:15 and 1:40 scale models. In no case could it be avoided without the use of the dentated bucket lip. Partly for this reason, and partly because it was desired to demonstrate the action of the proposed bucket in its entirety and its proper relation to the riprapped slopes of the tailraces, a complete model on a scale of 1:120 was decided upon. It was felt that such a model would obviate uncertainties introduced by the artificial conditions of the sectional models. A 1:120 model representing the complete ultimate development, including spillway, power houses, tailraces, and a half-mile of the river bed below the dam, was accordingly constructed in the Fort Collins laboratory. A view of this model is shown in one of the photographs.

The presence of the transverse wave was confirmed by the first observations made on the new model. By a process of trial and error, it was discovered that the action could be eliminated by increasing the effective tailwater depth. As a result of this finding, the design of the bucket was altered by lowering it until the crest of the lip was at El. 900.0. The results were completely satisfactory.

As the study of the transverse wave was proceeding, it was observed that the pool action in the vicinity of the tailraces was much less violent than had been anticipated. It was noted, furthermore, that the removal of one gate on the extreme left end of the spillway resulted in a very material improvement in the behavior of the tailrace. As a consequence, the spillway was shortened from a gross length of 1,800 ft to 1,650 ft. The resulting increase in effective head on the spillway crest fortunately had no adverse effect. This change permitted the shifting of the left power house to a position 150 ft nearer the river—a more favorable location, which will effect an appreciable reduction in construction cost.

Investigating Erosion of the River Bed

In order to study the erosion of the river bed, it was first necessary to select a material that would suitably represent the natural alluvium, and to determine a method by means of which the river-bed profile could be reproduced expeditiously. The bed material of the Columbia River at the Grand Coulee dam site is a combination of clay, sand, and gravel, closely interspersed with larger rock fragments, all intimately associated in a cohesive mass. To find an accurately analogous material was quickly seen to be a practical impossibility, but it was felt that satisfactory qualitative results could be obtained by the use of a cohesionless and less stable sand, since comparative rather than absolute data were desired. A design based upon conditions found to be satisfactory in this sand would be amply conservative when constructed in the tenacious material present at the site.

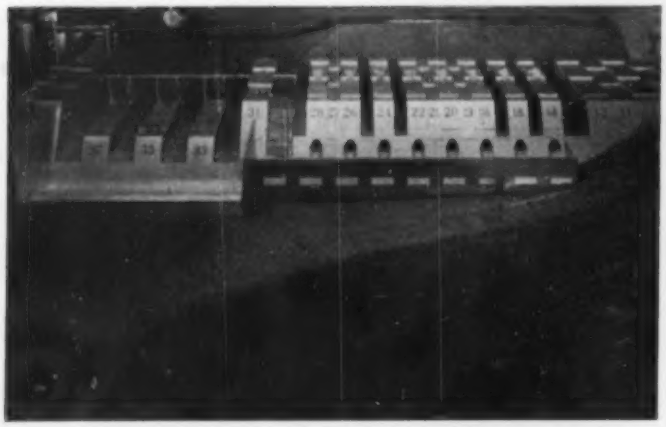


Measurements of Erosion in the River Bed of the 1:120 Model Were Recorded on the Profilograph in Prototype Terms

To facilitate the reproduction and recording of river-bed topography, a profilograph was developed which was similar in a general way to those in use in other laboratories, but embodied certain modifications. For example, a simple horizontal and vertical gear ratio was substituted for the more cumbersome pantograph. In an accompanying photograph, the instrument is shown in use. Field data were plotted in prototype dimensions on the profilograph sheets and automatically transferred in proper proportions to the model bed. Similarly, the measurement of the model bed after erosion had occurred was automatically recorded on the profilograph sheets in prototype terms.

Training-Wall and Crest Studies

Upon completion of the erosion studies, a further series of experiments was initiated on the 1:120 model for the purpose of improving the design of the spillway training walls. First consideration was given to the hydraulic properties of the walls. As originally proposed, they were of such length that considerable scour was produced by the eddies around their downstream ends. A small



THE 1:120 WEST COFFERDAM DIVERSION MODEL, WITH THE FLOOD PASSAGES FINALLY ADOPTED

number of tests sufficed to establish a length of wall for which the amount of scour would be reduced to a satisfactory minimum.

When the detailed structural designs of these walls were undertaken, it was found that no adequate data, either theoretical or experimental, were available as to the intensities of the unbalanced hydrostatic pressures to be expected. To provide the required information, one of the walls of the model was equipped with 64 piezometers so located as to give the vertical pressure distribution at six different sections. The tests showed that pressure differences were much less than had been assumed. The consequent redesign resulted in a material saving in both concrete and reinforcing steel.

A separate set of tests was made to assist in the design of the spillway crest and drum gate. The 28 by 135-ft drum gates necessitated the use of the unusually heavy vertical cantilever section shown in Fig. 3. It was desired to determine a crest shape which would coincide as nearly as possible with the natural trajectory of a freely falling jet. A tentative design was based upon data obtained from the Bazin experiments for a 2:3 approach slope. To check these assumptions, a model of the upstream portion of the crest, with a sharp-crested weir at El. 1,256.18, was constructed to a scale of 1:30. The lower nappe of the jet was then measured with a coordinometer. These measurements proved the trajectory to be in excellent accord with that arrived at by theoretical design. The trajectory thus measured was approximated by a compound curve with three radii, as shown in Fig. 3(a). This crest was then incorporated in the model, and pressure measurements were made with various discharges.

The pressure curves for the original design, Fig. 3(a), showed that a region of negative pressure was produced under all conditions of flow. The indications were that the curvature of the crest was too sudden near the downstream edge of the drum gate. To eliminate this low-pressure region, the radius of the large curve was lengthened, the axis of the crest moved upstream, and a parabolic curve introduced to connect the 66.25-ft curve to the 0.8 downstream slope of the spillway [Fig. 3(b)]. Subsequent testing of the revised section showed that the low-pressure zone no longer existed. After the revised design had been found satisfactory with the drum gate in the lowered position, additional measurements were made with the gate raised to provide pressure data for the structural design of the drum gates.

CONSTRUCTION DIVERSION STUDIES

Model studies have recently been completed to assist in the preparation of the diversion plans. These plans contemplated two major stages in the construction of the initial development of the dam. In the first, which is now in progress, a cofferdam along the left bank confines the river, which here flows north, to its normal channel and protects the construction in the west cofferdam area. After the completion of this work, it is proposed to shift the flow of the river into floodways provided across the newly completed work. This will be accomplished by removing the present cofferdams and constructing others across the present river channel to the right or east bank.

The problem presented for solution was the determination of a combination of flood passages through the west cofferdam area which would carry a maximum flood flow with the least menace to the riprapped slope at the downstream side of the power house tailrace. For this purpose, a technique was adopted on the diversion model, built to a scale of 1:120, which would provide the utmost

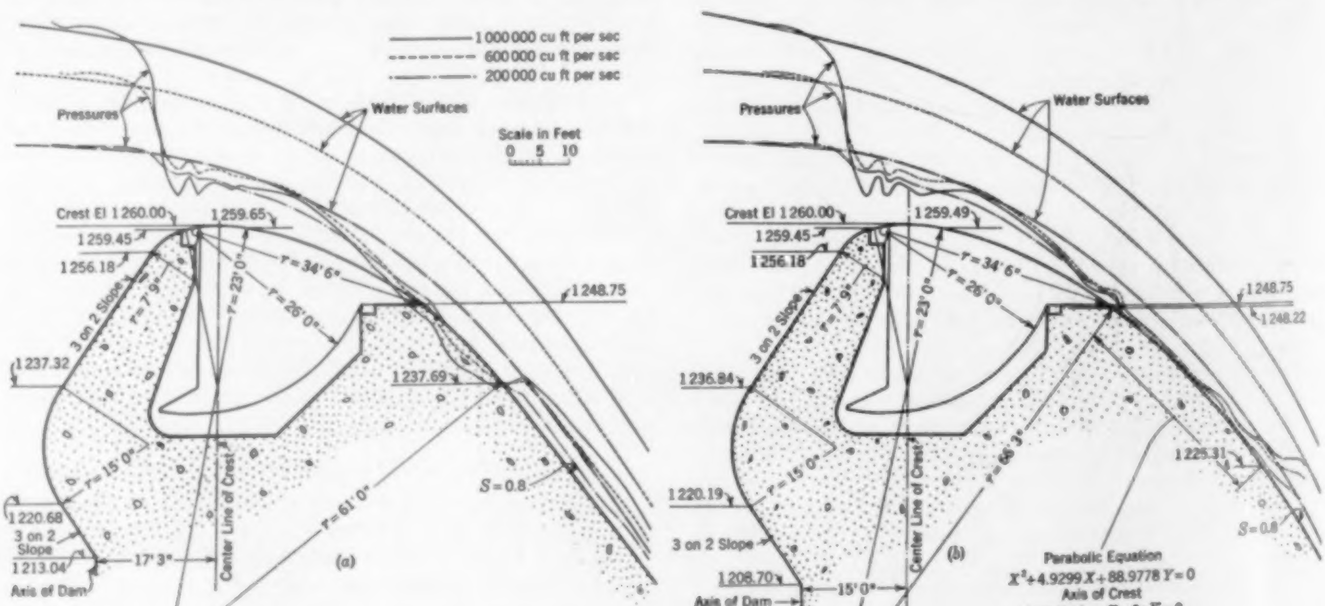
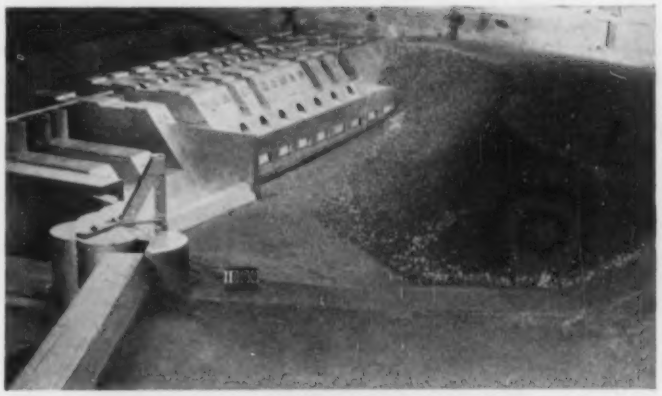


FIG. 3. CROSS-SECTIONS SHOWING ORIGINAL AND FINAL DESIGNS OF SPILLWAY CREST
(a) Original Design of Crest (b) Final Design of Crest

flexibility and thus permit rapid changes in the combination of flood passages. This was accomplished by the use of concrete blocks cast to simulate the actual blocks, but provided with horizontal joints to facilitate removal. The photographs show the combination of flood passages finally adopted. In the course of these studies, velocity and scour traverses were made for comparing the merits of the different plans. In addition, the headwater and tailwater elevations were recorded during each test as a possible aid to the construction engineer in determining the discharge during a flood.

In addition to the studies previously described, other experiments are either contemplated or actually in progress. Efficiency tests are now being made on a model of a turbine, complete with penstock, scroll case, and draft tube. Studies are in progress to assist in the design of the sluiceways and their control gates. Additional studies have been made on the 1:120 model of the ultimate development to determine the necessity for additional riprapping below the left tailrace. The present 1:120 model of the west cofferdam area is being extended to reproduce the entire initial development for further studies of flow conditions.

These hydraulic model studies for the design of the Grand Coulee Dam by the U. S. Bureau of Reclamation were initiated under the immediate supervision of E. W. Lane, M. Am. Soc. C.E., research engineer, and are being continued under my immediate supervision. Design studies and investigations are under the direction of J. L. Savage, M. Am. Soc. C.E., chief designing engineer. Engineering and construction work is under the general direction of R. F. Walter, M. Am. Soc. C.E., chief engineer, and the activities of the Bureau are under the general charge of John C. Page, acting commissioner.



View of West Cofferdam Diversion Model, Showing Riprapped Slope and Power House Foundation

Use of Models at Fort Peck Dam

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Several models were employed in the design of the Fort Peck project and were the basis for important improvements in certain features of the design. Hydraulic model studies were made of the spillway, one tunnel and the control structures, the complete tunnel outlet works, and the dam proper. The spillway models will be discussed first.

A plan and an elevation of the concrete spillway are shown in Fig. 1. The broad-crested weir has an elevation of 2,225 ft and a net length of 640 ft. Piers 12 ft wide support 16 fixed-roller vertical-lift gates, each 25 ft high and 40 ft wide, that control the upper 5,500,000 acre-ft of storage. The piers have tapering vanes on the downstream side extending 230 ft from the center line of the spillway crest, designed to reduce disturbances in flow below the gates. The discharge channel converges at varying rates from a width of 820 ft at the crest to 130 ft at the end of the lined section 5,200 ft downstream; a cut-off wall is provided at the end of the channel. The slope of the channel varies from zero at the crest to 5.2 per cent 2,000 ft downstream and then remains constant to the end of the concrete lining, providing for a total fall of about [illegible] ft.

The first model, and a second involving major changes, were constructed to a scale of 1:36 and required a maximum discharge of 33 cu ft per sec. Later, the lower end of the spillway was rebuilt to a scale of 1:25 for erosion studies, requiring a maximum discharge of 82 cu ft per sec. The overall length of the model was about 300 ft. Primary objectives in the model studies were (1) to establish the most efficient hydraulic design for the spillway structure, and (2) to determine the most efficient means of dissipating the kinetic energy at the end of the spillway paving.

Establishing Hydraulic Design for Spillway

A problem of considerable economic importance involved the allowance for freeboard to be provided in the side walls of the spillway. Any construction accentuating wave action would necessitate a greater freeboard allowance and would increase costs. Therefore, tests were conducted to ascertain the most efficient arrangement, length, and type of vanes and training walls for reducing turbulence downstream from the gates. The most satisfactory flow conditions were obtained with vanes extending 230 ft downstream from the crest. The piers tapered from a width of 12 ft at the crest to 11 ft at a point 44 ft downstream, and the vanes tapered from the latter width to a 2.5-ft bottom width 230 ft from the crest. Model tests indicated that training walls downstream from the vanes were not required.

Operation of the spillway with a number of gates closed resulted in the formation of standing waves of greater height than with all the gates discharging. Consequently, experiments were made to ascertain the best plan of operation if it should be found necessary to operate with certain gates closed. Wave action was at a minimum when the quantity discharged was broken up into comparable sections on each side of the spillway, and when the manipulation of the gates was synchronized during the opening and closing process. Under normal operating conditions, the same quantity of water will be released from each gate.

It was learned from experiments that abutments constructed to simulate half of a pier produced a more symmetrical flow than straight-wall construction, and occasioned less wave action in the lower part of the discharge channel. Moreover, the same quantity of water was dis-

charged with a lower head above the crest. Accordingly, in the design of the prototype the half-pier type of abutment was incorporated.

Measurements of water-surface profiles in the spillway channel were made for the maximum rate of discharge. The data were not directly transferable, but a check on

THE 1:25 SPILLWAY MODEL, SHOWING BEST ARRANGEMENT OF APRON, PIERS, AND DENTALS FOR CONTROLLING EROSION

the method of computing the profile for the prototype was afforded. A profile was computed for the model in the same manner as for the prototype, and the results were checked against data obtained from model experiments. The results checked well within the limits of experimental accuracy.

STUDYING DESIGN OF STILLING BASIN

Efforts towards the second objective involved a study of the effects of erosion under model discharge on a channel formed in fine gravel at the outlet of the spillway. A number of different forms and arrangements of baffle piers, dentals, and sills were tested to determine their efficiency in reducing erosion at the end of the spillway. Although the stilling-basin design developed from the model studies was not ultimately considered the most practical and economical plan for the Fort Peck spillway, the results of the tests are of interest and may be of value under other circumstances.

A preliminary test was run with the slope of the spillway channel set at 5.2 per cent. Turbulent conditions existed at the end of the concrete lining and downstream for a distance of about 8 stations, where the water surface reached a maximum elevation. As the downstream velocity of the water decreased, the water near each side of the main stream exhibited a tendency to flow back along the sides of the channel towards the end of the paving, because of the lower water surface at that point, and to again enter the downstream flow. The velocity of the water in these two main eddies was great enough to erode the banks for a considerable distance, the material being carried laterally into the main flow and then downstream until the velocity was reduced and a bar formed in the channel. It was apparent that in order to control erosion, the high point in the water-surface profile should be moved upstream as far as possible and paving provided from that point to the end of the spillway channel.

The maximum discharge and velocity expected in the prototype are 255,000 cu ft per sec and 100 ft per sec, respectively. The discharge channel will be 130 ft wide at the downstream end. A stilling basin capable of reducing the velocity of this quantity of water to less than scouring values without the use of some type of baffle piers would require a length and depth of such magnitude as to be very expensive. Moreover, tests indicated that without baffle piers the most efficient basin for the maximum rate of discharge was unsatisfactory for low and intermediate rates of flow. Consequently, tests were instituted to determine the best type and arrangement of dentals and baffle piers to spread the water near the end of the spillway channel and to form a hydraulic jump within a paved apron section.

Model tests indicated that the most efficient design should have the following features: A slope of 25 per cent for the lower 200 ft of spillway channel; a level apron 130 ft wide at the junction with the spillway channel and 200 ft wide at the downstream end, having a length of 300 ft and an elevation 45 ft below the bed of the river; side walls of the apron section warped uniformly from the slope of the spillway side walls to the slope of earth material downstream; three baffle piers resembling triangular truncated pyramids, one having a base of 40 ft and sides of 53 ft placed with the apex upstream 25 ft from the upper end of the apron, and two having bases and sides of 35 ft placed symmetrically 42 ft each side of the center line of the apron and 46 ft below the first pier; a 9-ft dental at the lower end of the apron and a 5-ft dental on the 25 per cent slope 60 ft from the upstream end of the apron. This type of structure completely eliminated erosive action below the apron of the model with the maximum rate of discharge, and was very satisfactory with the lower rates. The 5-ft dental diverts the water upward sufficiently to cause it to strike the first "splitter" pier well above the base and prevents the water from deflecting off the flat apron in a sheet. The three piers act to check the velocity of the water and to split the stream, causing the flow to fill the apron channel. The 9-ft plain dental at the lower end of the apron deflects the water upward near the bottom, has a tendency to counteract the downward velocity component of

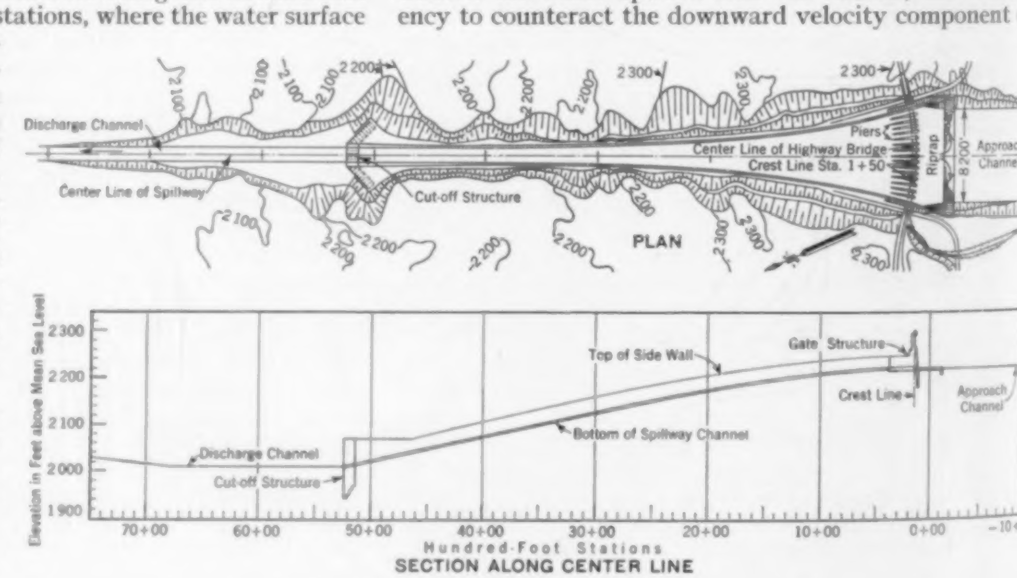


FIG. 1. PLAN AND SECTIONAL ELEVATION OF SPILLWAY, FORT PECK DAM

the water passing over the piers, and also forms a roller just downstream from the apron that draws material upstream to the dental. The velocity distribution in the flow leaving the apron is desirable, as the higher velocities are near the surface in their normal position.

TUNNEL MODEL HELPS IN FLOW STUDIES

The four diversion tunnels vary in length from about 5,200 to 7,000 ft, and have a maximum discharge capacity of about 20,000 cu ft per sec each. About 2,000 ft from the intake, the 24-ft 8-in. tunnels divide into two passages that gradually contract to openings 8.7 ft in width, and 17.1 ft in height (Fig. 2). Each passage is provided with a tractor-type vertical-lift gate for emergency control purposes. Downstream from the emergency gates, the two passages enlarge gradually and terminate in the annular space between two cylinders of the main control tower, the distance between the walls of the two cylinders being 6.5 ft. The inner cylinder contains six bell-mouthed ports, each 7.7 ft wide by 9.1 ft high, through which the water enters the inner tower and thence flows into the downstream tunnel. A 27.6-ft cylinder gate is provided for closing the ports and will be used exclusively for regulating the flow through the tunnel.

A model of one tunnel and the control structures was constructed of transparent celluloid, as shown in one of the photographs, so that flow conditions could be observed during tests. The scale of the model was 1:52, and the maximum discharge 1.1 cu ft per sec. The purposes of the model studies were (1) to investigate the behavior of flow with various methods of gate operation, reservoir levels, and rates of discharge to detect conditions that might be detrimental to the prototype structure; and (2) to derive coefficients for use in checking the computation of head losses in the control structures.

Much of the information derived from the tunnel-model experiments was of a general character, but valuable in determining the final design. Tests demonstrated the need for air vents just downstream from the emergency gate openings to relieve negative pressure when the emergency gates were partially closed, as well as the importance of synchronizing the manipulation of the two gates to minimize surging in the outer tower of the main control shaft. The transitions from the emergency gate openings to the annular section of the outer tower were improved, and the positions of the six ports of the cylinder gate were rotated 15 deg to provide a better approach for the flow. Bell-mouthing of the ports permitted a reduction in area without a loss in efficiency, and a 2-ft reduction in the diameter of the inner cylinder of the main control tower improved flow conditions in the outer tower and resulted in a substantial reduction in construction costs. A second cylinder gate located 80 ft above the first was found unnecessary for satisfactory operation of the reservoir.

STUDYING EFFECT OF AIR IN MAIN CONTROL SHAFT

The most objectionable flow conditions revealed by model tests occurred with intermediate rates of discharge and were caused by air entrained by the water as it entered the inner cylinder of the main control shaft. When the tunnel was discharging at its maximum capacity, the resistance in the tunnel downstream from the cylinder gate tower was great enough to sustain a column of water above the elevation of the cylinder gate ports, forming a pool in the inner tower and preventing the entrainment of air by the water flowing downward. However, as the discharge was reduced, the submergence of the ports became less until the water issuing from the ports was exposed to the air in the inner tower. The air was then drawn into the flow and carried downward into the lower tunnel, where it separated from the water and collected along the top of the tunnel under considerable pressure. After moving downstream to a point where the pressure resisting the flow became less than the pressure of the air, the air broke through and escaped through the downstream tunnel. This sudden release of

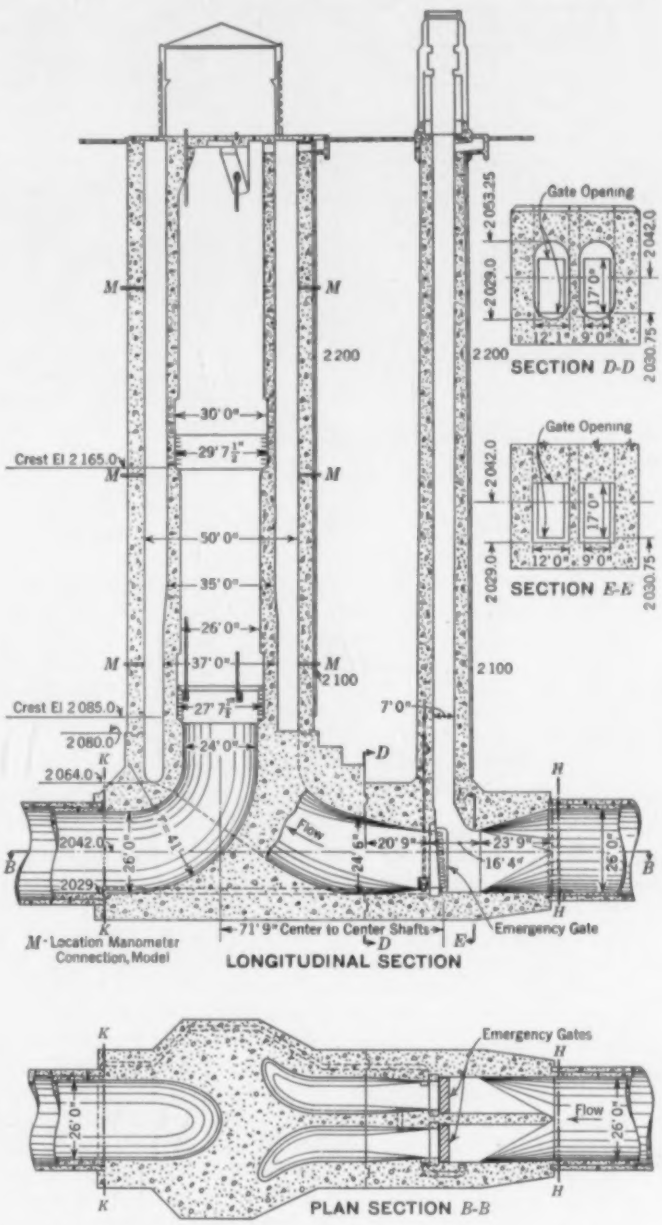


FIG. 2. SECTIONS OF CONTROL SHAFT, PRELIMINARY DESIGN, TUNNEL MODEL NO. 2, FORT PECK DAM

pressure resulted in excessive surging and unstable pressure conditions. When the discharge became so low that the entrained air was discharged continuously at the tunnel outlet, no unusual disturbance was produced.

Two plans for improving flow conditions in the tunnel with intermediate rates of discharge were investigated. The first plan provided for continuous removal of the entrained air by vents at a point near the main control shaft, thus preventing its sudden release farther downstream; the second plan involved sealing the inner tower to prevent the initial entrance of air.

The vents referred to were simply cylindrical chambers

installed in a vertical position on top of the tunnel to collect the air entrained at the inner tower after it had separated from the water. Two vents having diameters equal to three-fourths the internal diameter of the tunnel were required to materially reduce surging in the flow, one vent 130 ft from the main control tower and the other 400 ft farther downstream (prototype dimensions). In view of the results obtained in the model tests and the expensive construction involved, the vents were not considered justifiable.

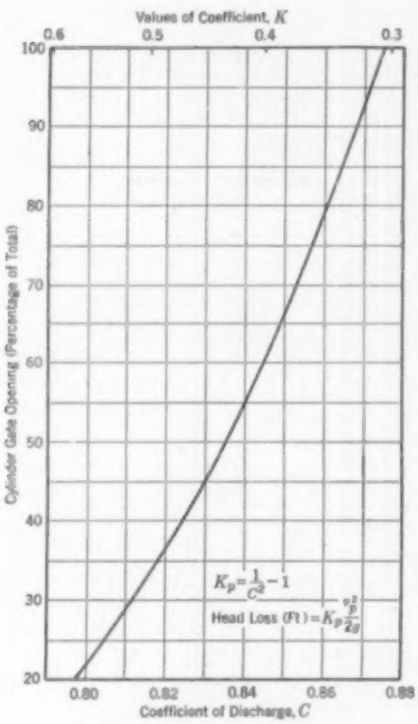


FIG. 3. COEFFICIENTS FOR LOWER CYLINDER-GATE PORTS WITH INNER TOWER UNSEALED

As Determined for Tunnel Model No. 2

By sealing the top of the inner cylinder of the main control shaft, contact between the atmosphere and the water entering the inside tower was prevented; consequently, entrainment of air was eliminated. Obviously, the improvements accomplished by sealing the inner tower pertained only to the intermediate rates of discharge previously affected adversely by the entrainment of air. An interesting phenomenon was witnessed, in model tests conducted with the inner tower sealed, as a result of the partial vacuum formed in the inner cylinder through the removal of air by the flowing water. These vacuums amounted to as much as 2 ft of water in some tests. Their formation added to the apparent reservoir level a part of the atmospheric head of 34 ft, and resulted in a greater discharge than would occur under the same conditions with the inner tower unsealed. However, the vacuum was formed only when the cylinder gate ports were not completely submerged inside the inner cylinder by backwater from the downstream tunnel, and consequently occurred only with the intermediate and lesser rates of discharge. No practical importance was attached to the increase in discharge under such conditions, but the reduction of the surging in the tunnel for intermediate rates of discharge was considered beneficial. The provision of valves for admitting air into the inner tower was believed to be advisable in view of the difficulties encountered under some conditions.

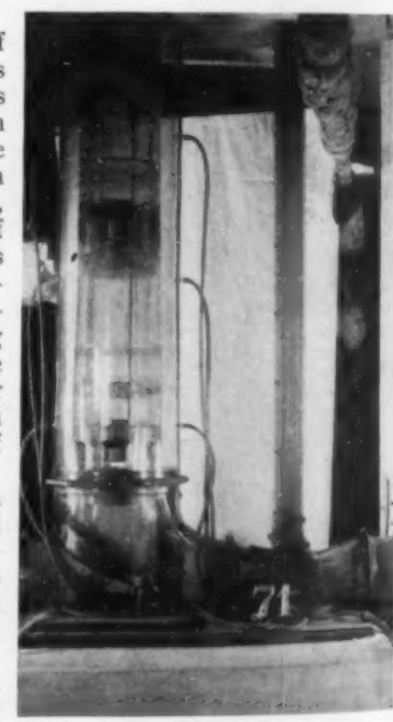
MEASURING HYDRAULIC LOSSES

Hydraulic gradients were measured in approximately 300 experiments, and the head losses in different sections of the model were computed in terms of $K h_v$, in which h_v equals the velocity head in the main tunnel, or $\frac{V^2}{2g}$. The results obtained were consistent within the range expected in this order of experimental work. The loss in the emergency gate structure was also determined by removing the structure and substituting a straight pipe in the model. Although there is always considerable uncertainty involved when model results are applied to large-scale structures, it is believed that the model tests furnished an excellent guide for a modified analytical determination of the probable hydraulic losses in the prototype. Although the coefficient K in the loss equation, $h_l = \frac{KV^2}{2g}$, generally decreases with increasing Reynold's numbers, it has been shown by experimenters that the change is small when the Reynold's number exceeds about 225,000. Since the Reynold's number for the model was 302,000 for the maximum discharge, it was assumed that bend and turbulence losses encountered with the higher rates of flow could be transferred from the model to the prototype in terms of $K h_v$ with but minor restrictions. Therefore, general formulas were used to subdivide the average overall losses in various parts of the model in order to ascertain the extent of their application to the conditions, and in some cases to determine the approximate value of the empirical constants involved.

TABLE I. HYDRAULIC LOSSES IN MODEL OF MAIN CONTROL SHAFT

LOSS ITEM	LOCATION AS SHOWN IN FIG. 2	HEAD LOSS IN FEET
1	Section H-H to Section E-E	$0.16\ h_v$
2	Section E-E to Section D-D	$0.42\ h_v$
3	Section D-D to entrance of cylinder gate ports	$0.33\ h_v$
4	Entrance of cylinder gate ports to Section K-K (ports fully open)	$2.52\ h_v$
	Total	$3.43\ h_v$

Special attention was given to the determination of hydraulic losses in the control towers. Average values derived experimentally for different parts of the model structures are given in Table I.



THIS MODEL OF TUNNEL AND CONTROL STRUCTURES PROVED HELPFUL IN STUDYING FLOW

Applications of suitable formulas indicate that losses due to contraction and friction are relatively small in Item 1 of Table I, the major part of the 0.16 h_v loss probably being occasioned by turbulence resulting from division of the flow into two water passages as shown in section B-B of Fig. 2.

The loss in Item 2 may be attributed (a) to sudden contraction at the emergency gate openings, and (b) to gradual enlargement from the area of the emergency gate opening to the area of section D-D. Brightmore's formula for sudden contraction, derived from experiments with 6-in. pipes with sudden contractions to 3 and 4 in., gives the loss due to contraction as

$$0.7 \frac{(V_2 - V_1)^2}{2g} \quad \ldots\ldots\ldots\ldots\ldots [1]$$

Substituting for V_1 and V_2 in terms of V, the mean velocity in a full section of the tunnel, gives the loss under Item 2(*a*) as

$$0.7\,(1.73 - 1.17)^2 \frac{V^2}{2g} = 0.22\,h_v \ldots\ldots\ldots [2]$$

The formula suggested by Andres for the loss due to enlargement and friction in a conical transition may be written,

$$f\,\frac{V_1^2 - V_2^2}{2g} \ldots\ldots\ldots\ldots\ldots\ldots [3]$$

Substituting for V_1 and V_2 in terms of V and estimating f as 0.10, gives the loss under Item 2(*b*) as

$$0.10\,(3.01 - 1.01)\,\frac{V^2}{2g} = 0.20\,h_v \ldots\ldots\ldots [4]$$

The sum of Items 2(*a*) and 2(*b*) is then 0.42 h_v, the value derived from model experiments. The coefficient of 0.7 in Eq. 1 should be increased to unity for large-scale structures.

The loss indicated by Item 3 strictly applies only to that part of the water passage for which it was derived. However, Eq. 3 may be solved for f and this coefficient used in solving for an approximate value of the head loss in structures closely resembling the water passage between section *D-D* and the cylinder-gate ports. The square of the velocity at the entrance to the cylinder-gate ports, in terms of the velocity in a full section of the tunnel, is 0.32 V^2, and the square of the velocity at section *D-D* is 1.01 V^2. Then

$$f = \frac{0.33}{(1.01 - 0.32)} = 0.5 \ldots\ldots\ldots\ldots [5]$$

The six cylinder-gate ports may be treated as a single orifice and the loss at the ports under Item 4 expressed as

$$\frac{K_P V_p^2}{2g} \ldots\ldots\ldots\ldots\ldots\ldots [6]$$

The ratio of the mean velocity head at the cylinder-gate ports at a point just inside the inner tower, to the velocity head in the tunnel is equal to the inverse ratio of the squares of the respective areas, or the loss at the ports equals

$$\frac{(A_t)^2}{(A_p)^2} K_p h_v \ldots\ldots\ldots\ldots\ldots\ldots [7]$$

in which A_t and A_p equal the areas of the tunnel cross-section and the cylinder gate openings, respectively. Values of K_p for partial openings of the lower cylinder gate of the model are shown in Fig. 3. The loss in the cylinder-gate ports of the model was 0.50 h_v when the ports were fully open.

When the tunnel is discharging at a rate great enough to cause backwater from the tunnel downstream to rise above the cylinder-gate ports, a loss results from the sudden enlargement of the water passage from the area of the port opening to the area of the tunnel cross-section. This loss due to enlargement is, approximately,

$$\frac{(V_p - V)^2}{2g} \ldots\ldots\ldots\ldots\ldots\ldots [8]$$

If $\frac{A_t}{A_p} V$ be substituted for V_p, then the loss becomes

$$\left(\frac{A_t}{A_p} - 1\right)^2 h_v \ldots\ldots\ldots\ldots\ldots\ldots [9]$$

This enlargement loss was negligible (0.02 h_v) when the cylinder gate was fully open, but was appreciable when the ports were partially closed. Discharges that are entirely controlled by the resistances upstream from the inner tower obviously will not be affected by this enlargement loss.

In the model studies, the overall loss from the cylinder-gate port entrances to section *K-K* was determined from

A 1:70 MODEL OF THE OUTLET STRUCTURE

Paved Sections Were of Pressed Wood; Excavated Channel of 1:8 Cement and Loess

measurements of the hydraulic gradients. It was found that by subtracting the port loss and enlargement loss, computed as previously explained, from this overall loss, a fairly constant residual value was obtained that apparently represented the turbulence and bend loss in the 90-deg elbow of the main control tower. An average value of 2.00 h_v was computed from the test data. Later a series of tests was run with the control structures removed from the model and replaced by a straight pyralin pipe in order to determine the influence of the control structures on losses in the tunnel immediately downstream. No important difference in loss was evidenced in these tests, however.

TESTS ON TUNNEL-OUTLET MODELS ARE STILL IN PROGRESS

The outlet structure consists principally of a level concrete apron placed on firm shale at the elevation of the bottom of the tunnel outlet portals, with retaining walls at the sides high enough to provide for the maximum level of tailwater. To study flow characteristics under critical conditions of discharge, tailwater elevation, and with various tunnels operating, a model was constructed to an undistorted scale of 1:70. A number of plans for improving flow conditions have been investigated, but tests are still under way, and definite conclusions have not been reached.

In connection with studies to determine the suitability of the various soils available at the site of the Fort Peck Dam for building an earth-fill structure, and to aid in the design of a stable section for the dam, nine model earth dams were built. Six of the models were constructed of Missouri River valley alluvium, a silt sand. This material was sluiced into the model flume from elevated mixing tanks in imitation of hydraulic dredging. Two other models were constructed from a clayey glacial till by modern rolled-fill methods, and a final model was constructed of the same materials that are now being placed in the prototype. Observations were made on all earth models to determine the position of the line of saturation, rate of seepage, stability, and mechanical distribution of material.

MEADOWBROOK CAUSEWAY BRIDGE OVER THE STATE BOAT CHANNEL

Long Island State Parks and Parkways

A Comprehensive System of Traffic Arteries Gives Access to Attractive Recreation Areas

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EMBRACING almost all the salt-water frontage of the state of New York, and with its western extremity forming an integral part of New York City, Long Island is ideally situated for recreation of dwellers in the metropolitan area. The Long Island State Park Commission now administers 15 state parks, all but one of which have been created since 1924. It has also completed about 85 miles of state parkways, including 132 grade-separation structures. The largest park is the 6,000-acre Jones Beach development, established on a sand reef on the south shore of Long Island about 30 miles from the city, at a cost of $15,000,000, including 32.5 miles of parkways, 22 bridges, and 10 pedestrian underpasses, in addition to the buildings and recreational facilities. Mr. Shapiro also discusses in some detail the entire parkway system on the island, both existing and proposed. In planning these wide arteries with their ornamental stone-faced crossing structures, landscaping and other esthetic considerations played an important rôle.

PHYSICALLY, Long Island resembles a giant fish, with its mouth in New York Bay. One hundred and twenty-two miles long, it stretches from Ambrose Channel to Montauk Point. It is about 23 miles across at its widest part. Two ranges of hills, averaging 150 ft in height, provide topographic relief for the two easterly flukes forming the tail of the fish. Gradually, these ranges converge and finally come together north of the center of the island, reaching a maximum height of 426 ft. They then continue westward together to a point near the New York City line. Here the moraine winds along to the Narrows in Brooklyn, in places reaching a height of about 300 ft.

South of these ranges the terrain is fairly level and dips toward the sea. From a gently sloping plain, the land gradually passes into a salt marsh enveloping a number of broad shallow bays. The outer beach on the south shore, except at the east end, is made up of a series of long, narrow, sand reefs, separated at intervals by ocean inlets. The easterly beaches are principally gravel headlands, resulting from glacial deposits and the littoral movement which carries sand steadily from east to west. The north shore of the island is rugged, precipitous, and deeply serrated, with long, narrow valleys and streams. The plains between the double range of hills are fairly level, and are marked here and there by small streams and ponds, and by circular depressions known as kettleholes. The land has a glacial appearance and at one time was heavily timbered.

On the westerly end of Long Island resides over half the population of the City of New York and one-third the population of the entire state. In the four counties of Kings, Queens, Nassau, and Suffolk, of which the first two are part of New York City, a total of 4,500,000 persons make their homes. A vast network of bridges, highways, and tunnels link Long Island closely with Manhattan; and the Triborough Bridge, with its connecting system of parkways and highways, opens up an entirely new route between Long Island and the Bronx, with a connection to Manhattan.

STATE COUNCIL OF PARKS CREATED

In 1923, New York State embarked on a comprehensive statewide plan for the scientific development of a unified system of parks and parkways. The plan was founded on the report of an unofficial committee of citizens interested in the principles of state park planning, which completed an investigation of conditions then existing and recommended to the legislature the broad concept of a new state park system. To make the plan operative, the legislature in 1924 created the State Council of Parks with Robert Moses as chairman. The Council, which acts in a supervisory capacity, is in reality, a central planning agency and clearing house for the park developments of the state. In organizing, the Council consolidated the 42 assorted agencies which at that time administered the various complex holdings of the state, comprising public gathering places, museums, parks, and historic sites; and instead, divided the state into 11 regions, of which Long Island forms one. Through the various regional park commissions, the Council today administers a system of 70 parks which extend from Lake Erie to Jones Beach, and provide recreation for about twenty-three million visitors annually.

The Long Island State Park Commission, a regional member of the State Council of Parks, was created by the New York State Legislature in 1924 to provide for the location, acquisition, and improvement by the state of a park and parkway system on Long Island. At that time, out of a total combined area in Nassau and Suffolk counties of 864,000 acres, there was only one pa.k under state supervision. This was Fire Island State Park, 118 acres in extent, located out on the barrier beach, where it was accessible by boat only. It should be borne

in mind that it is not unusual for a city, county, or metropolitan area to set aside from 5 to 10 per cent of its total area for park and playground purposes and public open spaces. On Long Island, large areas in undivided ownership were rapidly disappearing, particularly shore-front properties. As the population grew and the number of suburban dwellers increased, the area of open space and shore front diminished. Encroachment by private interests upon what should be public land became more marked. This situation was accurately described and the keynote of the Long Island program sounded by Robert Moses in "The State Park Plan for New York" in 1923:

"There is a current theory that there is an inherent conflict in suburbs of great cities between the demands of the public for parks and parkways and the vested rights and interests of local residents and owners of large estates who have already preempted most of the best locations. There is no such conflict. As a matter of fact, the best interests of local property holders are served by intelligent long-term planning for public facilities, not only because parks and parkways belong to the local people five days in the week, but also because it is only by such planning that local residents can prevent overcrowding of roads, trespassing on private property, and other results of the irresistible pressure of the masses to reach the shore and the countryside. The program which is proposed on Long Island will protect the landscape, provide for the public, and prevent private owners from being overrun by making adequate provision for public facilities. It does not matter whether this subject is approached from the point of view of conservation of natural resources, national health and efficiency, or enlightened selfishness—the paths all lead to the same conclusion."

OBJECTIVES OF THE PARK AND PARKWAY SYSTEM

In formulating the general park and parkway plan for Long Island, there were two objectives: First, the establishment of a parkway system to furnish access to the individual parks from congested centers of population and to provide for travel between New York City and Long Island on attractive routes without interference from commercial traffic; and second, the acquisition of as much land as possible on Long Island, particularly along the shore, in order to provide the maximum of park property for future public use.

The Long Island park and parkway system today is 20,580 acres in extent (Fig. 1), embracing 15 parks located along both the north and south shores of the island and in its interior. The huge Jones Beach project and the 1,374-acre Bethpage Park, the newest addition to the system, together with Hempstead and Valley Stream state parks, are all within an hour's drive by way of the parkways from some of the most congested sections of New York City. A half-hour's drive further east are Sunken Meadow, Belmont, and Heckscher parks, located near the west end of Suffolk County. The most distant parks are Wildwood, Orient, Hither Hills, and Montauk, the so-called nature parks, extending out into the extreme east end of Long Island. Last year five and one-half million people visited these parks.

Bascule Bridge Carrying the Wantagh State Parkway from the Mainland to Jones Beach

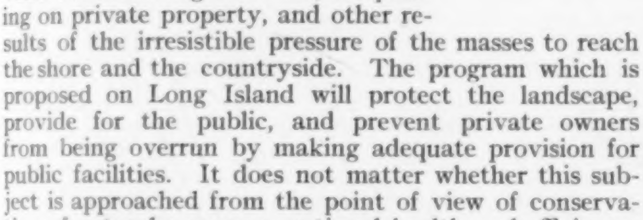

Fig. 1. Long Island, N.Y., Showing Location of Thirteen Principal State Parks

Manifold problems are involved in the operation of facilities in a system of this size. These include not only the conventional engineering problems of providing potable water supplies, sewage-disposal facilities, adequate parking areas, playgrounds, and the various other standard park facilities; but also involve the solution of incidental problems and the promulgation of rules for zoning, policing, employing personnel, establishing ordinances, and many other complex phases of park operation.

The history of Jones Beach merits special mention, since it typifies on a large scale the problems encountered in the development and expansion of the entire system. Of this state-owned and state-operated ocean-front resort, H. G. Wells, in his *Work, Wealth and Happiness of Mankind*, says, "It is one of the finest beaches in the United States, and almost the only one which has been designed with forethought and good taste."

MODEL PARK CONSTRUCTED AT JONES BEACH

From the very beginning of the Long Island park movement, recognition was given by the Commission to the lack of an accessible publicly owned and operated ocean-beach park, not only for the pleasure of holiday seekers from New York City, but for the entire metropolitan area as well, including the rapidly growing Long Island counties.

In view of the outstanding advantages of Jones Beach as far as natural topography, extent of beach, and proximity to New York City were concerned, the desirability of its acquisition and development for the use of the public was obvious. With accessibility ensured, its recreational possibilities would be unlimited. The land was owned by the townships in which it was located. With the goal in view of establishing an ocean-front park

within 30 miles of New York City, the Commission secured control of the land, by vote of the townspeople, with the result that over 6,000 acres of beach, meadow, and land under water were turned over to the state for park development.

The first causeway to Jones Beach State Park, running

WIDE, LONG-RADIUS CURVES WERE USED AT THE INTERSECTION OF THE MEADOWBROOK CAUSEWAY AND THE LONG BEACH SPUR

from the mainland of Long Island at Wantagh, was opened to traffic in the summer of 1929 (Fig. 2). This parkway, which is 5 miles long, consists principally of hydraulic fill connecting the group of meadow islands along the route, with bridges over the navigable channels. To procure the 2,000,000 cu yd of material necessary for the foundation fill, a channel was dredged from the mainland to the beach, parallel to the causeway.

The bridges, of concrete pile-bent construction, were built at a cost of approximately $5 per sq ft. The bridge nearest the mainland is 100 ft long, with a vertical clearance of 15.6 ft at low water. The next bridge, crossing what was then the principal boat channel, is 520 ft long between abutments, and is provided with a 75-ft clear-span double-leaf bascule, with a clearance when closed of 23.6 ft above mean low water. The third bridge is 575 ft long, with a center clearance of 17.6 ft above low water. Each bridge has a 6-lane roadway and two 5-ft sidewalks. The present causeway pavement is 40 ft wide. The total cost of construction, including bridges, was approximately $1,900,000.

In 1934, a second wide motor causeway, known as the Meadowbrook Parkway, was completed across the marshes from Freeport to the westerly end of Jones Beach State Park. This causeway was built by the Long Island State Park Commission, acting as the Jones Beach State Parkway Authority, and was financed by a $5,050,000 loan obtained from the Reconstruction Finance Corporation. Under this project, the Long Beach Loop Causeway was completed, as well as a second entrance to Jones Beach. This branches off from the main causeway, swings in an arc back of Jones Beach, and connects with the principal thoroughfare to the city of Long Beach and points west.

Six additional bridges over navigable channels were built under the new project, including two bascule bridges. Concrete piles up to 95 ft in length were driven for the trestle approaches. Individual piles weighed 30 tons in many cases. The work of casting, handling, and driving the 1,726 concrete piles in this project was carried on throughout one of Long Island's severest winters. In addition to the six channel bridges, there were erected three stone-faced elliptical-arched grade-separation struc-

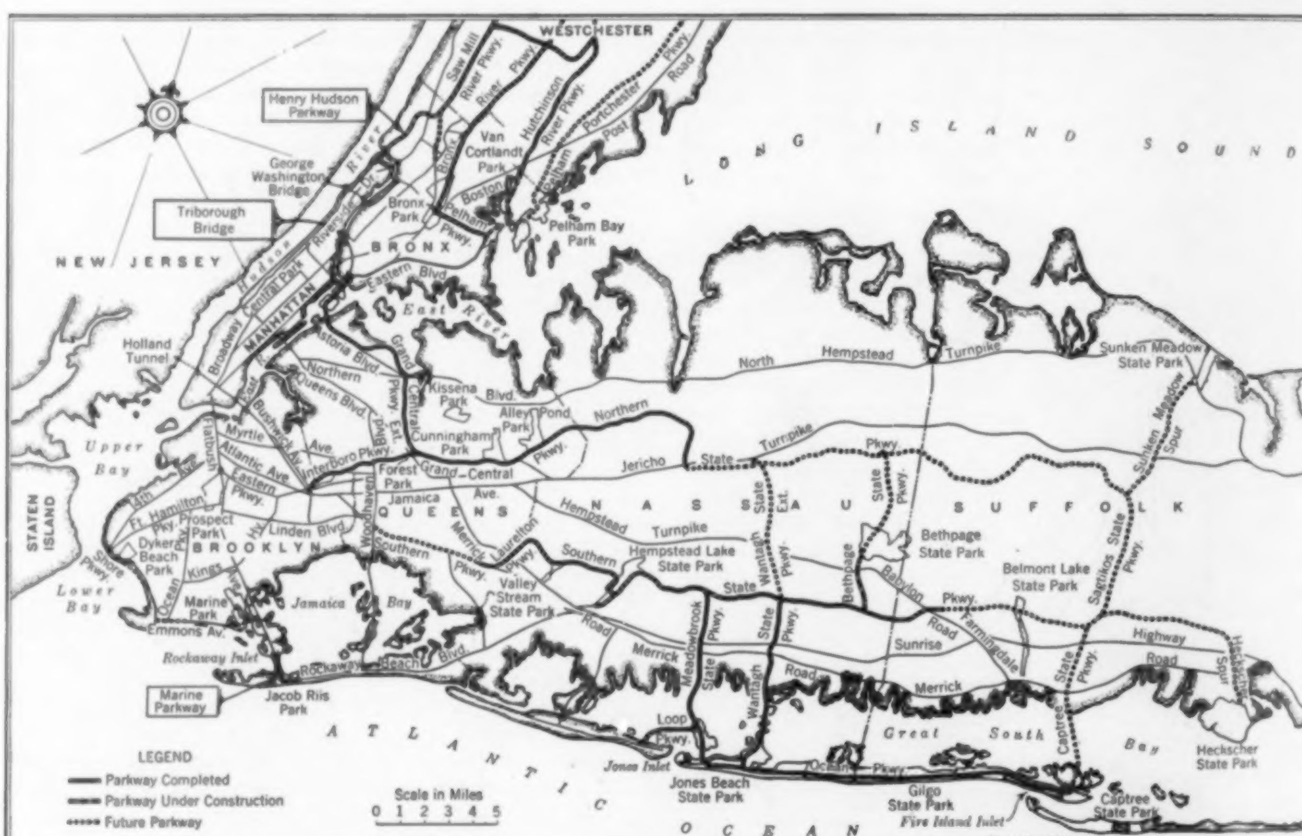

FIG. 2. EXISTING AND PROPOSED LONG ISLAND STATE PARKWAY SYSTEM, WITH CONNECTIONS TO NEARBY COMMUNITIES

tures, eliminating grade crossings at the north and south ends of the main causeway and also at its intersection with the Long Beach connection. The latter structure is shown in one of the photographs.

A wide ocean parkway has been completed for 17 miles along the beach proper. Monumental brick and stone structures at Jones Beach provide bathhouse accommodations for 15,000 persons. Restaurants, swimming pools, a mile-long boardwalk, and 76 acres of concrete parking areas are among the other features (Fig. 3). Besides the beaches on the ocean side, which are available for surf bathing, a still-water bathing beach has been developed on the bay side. Bordering the development on the north runs a 20-mile boat channel. The entire improvement of Jones Beach State Park, including the Ocean Parkway and the two causeways connecting with the mainland, represents an expenditure of $15,000,000.

Completion of the Reconstruction Finance Corporation project made Jones Beach State Park accessible from two points on the mainland and from the easterly end of Long Beach. This rounded out the development of Jones Beach as far as the westerly section was concerned. At the extreme easterly end of the long narrow beach, another connection with the mainland will be built, as shown in Fig. 2. This is the proposed third causeway from Captree Island to the mainland east of the village of Babylon. Incorporated within the Captree Causeway will be a 7,900-ft structure over Great South Bay. Thus, the formerly unknown and inaccessible strip of beach land will be hooked up with the mainland at each end of its 17-mile length, providing a continuous and unbroken parkway drive along ocean and bay.

SOME ADVANTAGES OF PARKWAYS

Parkways, like parks, can be planned and built so that they combine sound engineering and good taste. A wide landscaped parkway without crossings at grade and with only limited access will carry, without inconvenience or crowding, three or four times as many cars as the conventional highway of equal pavement width. This is primarily due to the elimination of left-hand turns and relief from the stopping and starting which result from traffic lights. Thus, a parkway provides enjoyment for many more people on one thoroughfare by the comparatively simple device of careful selection of site and proper planning of construction to afford a route which is attractive and protected, instead of one which is unsightly and unrestricted. In effect, a parkway is a narrow landscaped park with a pavement for motor vehicles running through it. Crossings at grade are eliminated and access is afforded only at fixed and specified entrances, which are spaced a considerable distance apart and are not opposite each other. The average width of a parkway right of way is about 300 ft, depending on topography, cost, and other factors.

There are at present on the Long Island parkway system 132 ornamental stone-faced bridges separating grades. These are designed not only for strength but for appearance. The architect and the landscape architect take part along with the structural engineer in designing the structures and preparing the plans. The concrete pavement for the roadway proper is treated with coloring matter so that the white glare normally associated with concrete surfaces is eliminated. The modern parkway pavement presents an appearance that blends in as harmoniously as circumstances will permit with the surrounding park-like appearance of the territory through which the route passes. Other considerations, such as lights and light poles, walks, trails, planting, and landscaping are all as integral a part of the parkway construction as are the bridges and concrete roadways.

VIEW OF JONES BEACH STATE PARK, SHOWING BEACH, PARKING AREAS, AND ENTRANCE FROM WANTAGH CAUSEWAY

Today, the parkway system on Long Island represents one of the most comprehensive networks of automobile arteries in existence. From the breaking of ground on one of New York City's water supply properties a decade ago along the south shore of Long Island, the system has been developed until it handles 18,000,000 vehicles a year. It now extends from the Triborough Bridge approach in northern Queens County to the end of the Ocean Parkway on the south shore of Suffolk County, and comprises 85 miles of completed parkway. Funds for construction were obtained through state and federal-aid highway appropriations, supplemented by loans from the Reconstruction Finance Corporation and the Public Works Administration. Rights of way were provided by Nassau and Suffolk counties, by the City of New York, by dedication, and in a few instances by direct purchase.

PRINCIPAL PARKWAY ARTERIES

Basically, the framework of the Long Island parkway system consists of a principal artery along the northerly part of the island and a second along the south. The first, known as the Grand Central–Northern State Parkway, runs through one of the most heavily populated sections in the country, in Queens and Nassau counties. Beginning at the Triborough Bridge approach at St. Michael's Cemetery, Astoria, the Grand Central Parkway swings along the edge of Flushing Bay to Northern Boulevard; down through the Flushing Meadows, site of the proposed 1939 World's Fair, to Kew Gardens; and then east along the backbone of the island to the Nassau County line. From this point it continues as the Northern State Parkway east to its present terminus at an intersection with the Jericho Turnpike, about

A TYPICAL VIEW ON A LONG ISLAND STATE PARKWAY

one-third of the distance through Nassau County. The total length from the Triborough Bridge approach to the present easterly terminus is 20 miles, all of which is complete and open to traffic. A 5-mile spur, the Interborough Parkway, provides a connection between the Grand Central Parkway and a series of important thoroughfares in Brooklyn converging at Pennsylvania and Jamaica avenues. All told, the Grand Central–Northern State Parkway, with the Interborough connection, consists of 25 miles of pavement with a minimum width of four lanes, and includes 68 grade-separation bridges, all but four of which are granite-faced structures. This parkway carried thirteen million vehicles in the 12 months from August 1935 to August 1936.

From the present easterly terminus of the Northern State Parkway in Nassau County, most of the right of way has been obtained for an extension easterly through the rest of Nassau County and for about 10 miles in Suffolk County, where a connection (Fig. 2) will be made with the proposed cross-island parkway connecting Sunken Meadow State Park on the north shore with the Ocean Parkway on the south.

The second major artery in the Long Island system is the Southern State Parkway. To date, this parkway has been completed from the Sunrise Highway at Laurelton, in the extreme southeasterly corner of Queens, through Nassau County into Suffolk County, where it terminates at present a few hundred feet across the county line. The total length of completed parkway is 24 miles, and there are 37 grade-separation structures. Extension of the Southern State Parkway is under way on both the east and west ends. The work on the west end consists of the conversion of the present Sunrise Highway into a genuine parkway, with a further extension ultimately along the south shore of Brooklyn by way of Marine Park to a connection with the Shore Parkway, now under construction at Fort Hamilton. On the east end, the Southern State Parkway extension involves completion of the parkway to the cross-county connection from Sunken Meadow State Park to Captree Island State Park. A short spur, the Bethpage Parkway, has just been completed and connects the Southern State Parkway with Bethpage State Park.

At Meadowbrook State Park and at Wantagh along the Southern State Parkway, spurs to the south extend across the bay to Jones Beach State Park, as previously mentioned. The Jones Beach system, embodying the Meadowbrook and Wantagh parkways and the Ocean parkway, is $32^1/_2$ miles in length.

Coordination of the various state and city agencies participating in the program is made possible under the direction of Robert Moses, who is head of the State Council of Parks, of the Long Island State Park Commission, of the New York City Park Department, and of the Triborough Bridge Authority. Arthur E. Howland is chief engineer of the Long Island State Park Commission; J. J. Darcy, district engineer for the State Department of Public Works; and W. Earle Andrews, general superintendent of the New York City Park Department. Arthur W. Brandt is commissioner of highways for the state of New York.

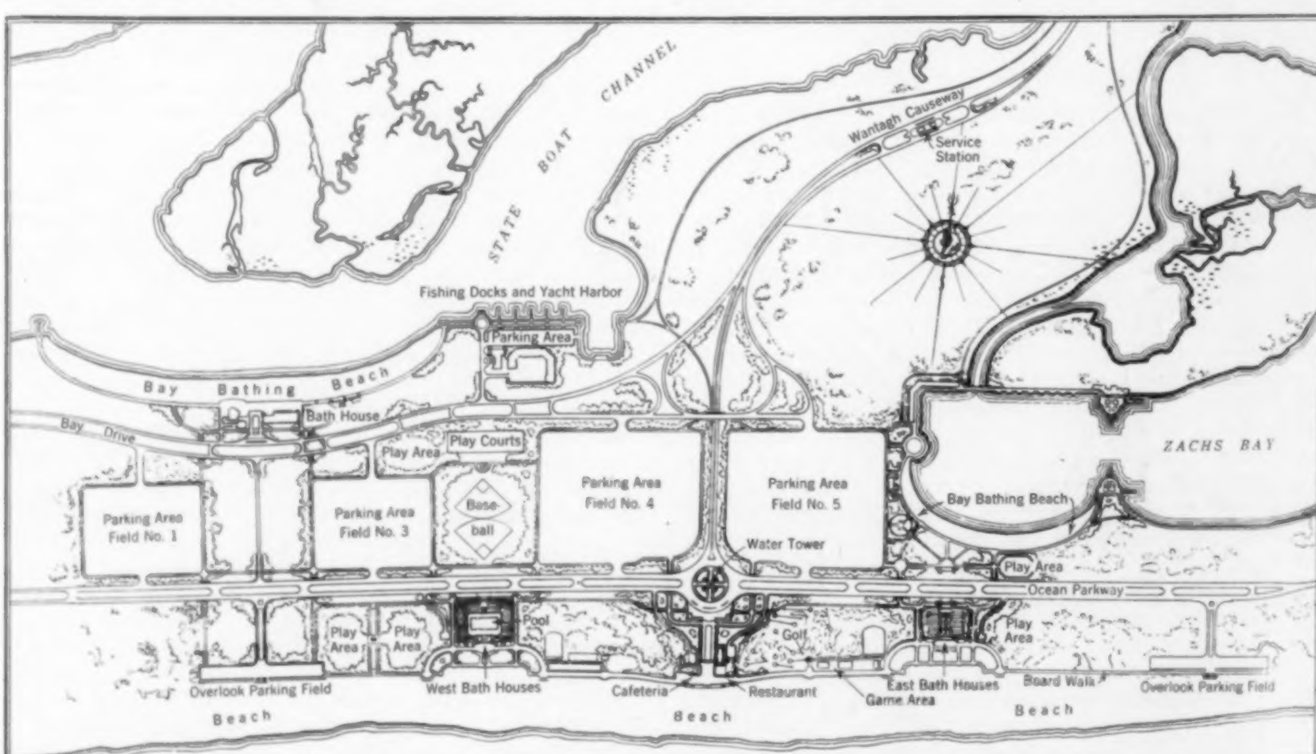

FIG. 3. GENERAL PLAN OF JONES BEACH STATE PARK

Grouting Boulder Dam Tunnels

Describing the Equipment and Field Methods Developed for Pressure Injection Work

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APPROXIMATELY 235,000 cu ft of cement for grout, or more than 50 per cent of the total amount placed at Boulder Dam, was used in grouting 22 of the tunnels and their appurtenant works. Eighty per cent of this grout was injected through the walls of the 50-ft diversion tunnels, which thus offered plenty of opportunity for the development of efficient methods for mixing and placing grout under pressure and for sealing the inevitable leaks. In this article, Mr. Minear describes the mechanical equipment of the portable grouting plant in some detail and then passes on to the basic principles underlying the work itself. In connection with this paper, readers may wish to refer to the article discussing the grouting as a whole, "Designs for Grouting at Boulder Dam," by A. V. Werner, published in the September 1936 issue.

IN pressure-grouting 22 tunnels (exclusive of the large inclined spillway tunnels) at Boulder Dam, more than 235,000 sacks of cement were injected at pressures ranging from 50 to 750 lb per sq in. This work was begun in August 1932 and was completed in March 1935.

The plan followed in grouting the 50-ft diversion tunnels, which constituted the bulk of the work, is shown in Figs. 1 and 2. Tables I and II give synopses of the cement placed in the diversion tunnels and adjacent parts. Tables III and IV are summaries of the low- and high-pressure grouting in terms of cubic feet per square foot of rock area and cubic feet per linear foot of drill hole, respectively. Table V is a summation of the regular grout-hole drilling in the diversion tunnels.

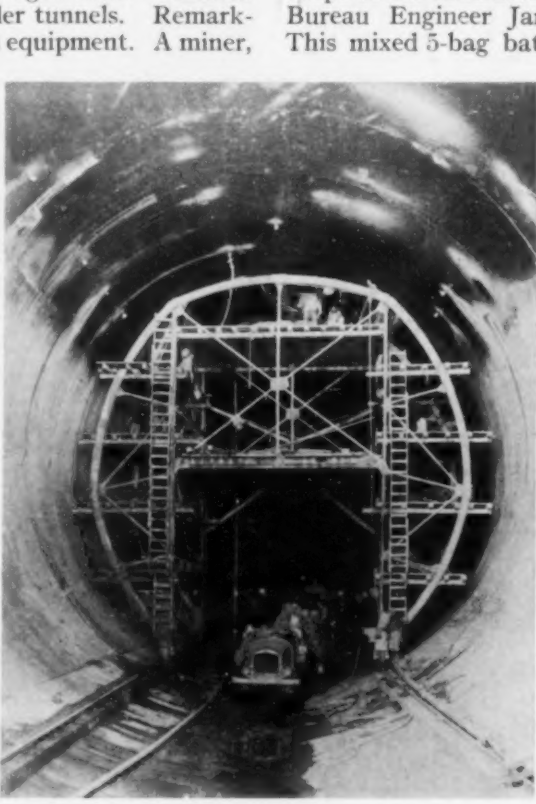
Drilling of the side walls and arch of the 50-ft diversion tunnels was done with 14 sets of drilling equipment, mounted on a movable scaffold or jumbo which traveled on 90-lb rails that had been laid for concreting the side walls and arch of the tunnel lining. Invert holes were drilled with a "wagon drill." Similar equipment was used for the smaller tunnels. Remarkable progress was possible with this equipment. A miner, with a nipper and a chucktender, could drill 600 lin ft of high-pressure holes in one and one-half 8-hour shifts. This is thought to be a record.

Grout-placing equipment (shown diagrammatically in Fig. 3) consisted of a mixer, a mechanically agitated sump, two 10 by $4\frac{1}{2}$ by 10-in. high-pressure mud pumps using $3\frac{3}{4}$-in. liners for low pressure and $3\frac{1}{16}$-in. liners for high pressure, and $1\frac{1}{2}$-in. high-pressure rubber hose. This equipment gave excellent service, and except for a few minor replacements and changes, is the same with which the job was started.

Pumps of the type used are ideal for placing grout. They permit a close control of pressure, are flexible in that the rate at which grout is injected can be varied at will, and are safe. In the beginning, when pumping into a hole that required several hours to fill, the pump valves became fouled with partially set grout and the passages were obstructed. Considerable difficulty was experienced in this matter, and it was necessary to tear down the pumps as often as once a shift in order to chip out the hardened grout. As complete shutdowns were permitted only when unavoidable, a standby pump was provided. After some experience, we could tell from the sound of the exhaust and the general behavior of the pump when it was beginning to become fouled. Then, if water was circulated to the full capacity of the pump for about one minute, the hardening grout could be washed out. Chipping became a thing of the past and was only necessary at times of routine overhauling.

Various types of portable concrete mixers were used, but they all proved unsatisfactory owing to excessive wastage of cement. Furthermore, the devices provided for measuring the mixing water did not permit the wide variation in water-cement ratio essential for best results in grouting.

The most satisfactory mixer used was fabricated in the shops of the contractor, embodying many ideas of former Bureau Engineer James B. Hays, M. Am. Soc. C.E. This mixed 5-bag batches of grout of 1.00 water-cement ratio by volume or thicker. It consisted of a horizontal cylindrical tank 30 in. in diameter and 4 ft in length, equipped with a horizontal shaft having four sets of blades. It was operated by an air-driven motor at an average speed of 100 rpm. Cement entered through a hopper in the top at one end, and water was fed through three nozzles in the end just below the hopper. The grout was discharged through a plug valve in the bottom at the opposite end of the tank.



High-Pressure Grouting Jumbo in Tunnel No. 4
Note Hose Connection at Upper Left of Photograph

Mixing water was controlled by a disk-type meter with a 6-in. vertical dial, having scales reading to tenths of a cubic foot and a totalizer. This gave great flexibility and afforded a continuous check on the amount of water and cement injected.

From the mixer, the grout was discharged into an agitator or sump, consisting of an open-top tank 3 ft in diameter and 2 ft deep, which provided a storage supply equal to two batches to ensure a continuous flow from

TABLE I. SACKS OF CEMENT USED IN GROUTING DIVERSION TUNNELS TO JULY 1, 1935

Tunnel No.	Invert			Arch			High-Pressure Work			Total		
	Placed	Waste	Total	Placed	Waste	Total	Placed	Waste	Total	Placed	Waste	Total
1	7,766*	39	7,805	26,184	131	26,315	15,224	87	15,311	49,174	257	49,431
2	4,861	22	4,883	30,207	187	30,394	10,496	85	10,581	45,564	294	45,858
3	4,426	132	4,558	24,369	237	24,606	4,617	63	4,680	33,412	432	33,844
4	4,001	54	4,055	31,457	338	31,795	24,027	191	24,218	59,485	583	60,068
Totals	21,054	247	21,301	112,217	893	113,110	54,364	426	54,790	187,635	1,566	189,201

* Includes 4,562 sacks in invert drain—Tunnel No. 1 plug not completed.

the pump. In the beginning, the grout in the sump was stirred manually. Since many holes that had been taking grout freely refused it shortly after a change of shift, it was suspected that this was due to settlement of the grout while the shift was being changed. This difficulty was eliminated by installing a mechanical agitator consisting of a propeller shaft with two blades set close to the bottom of the tank, operated by an air-driven motor at a speed of about 30 rpm.

The mixer, sump, and pumps were mounted on a 5-ton truck. Cement was supplied by a second truck which was backed up to the first.

NEAT CEMENT GROUT FOUND BEST

Various mixtures of sand and cement were tried, but the use of sand was found to be unsatisfactory and was discontinued. Thereafter, neat cement grout was used. The undesirability of passing a sanded mixture through the pumps is self-evident. However, the principal objection to its use is the difficulty of holding the sand in suspension. It settles out of the grout stream, clogging the pipe and fittings, as well as the hole.

Standard portland cement was used for the bulk of the grouting in the tunnels. Screened cement, 98 per cent of which passed a 200-mesh screen, was tried. While more screened than unscreened cement can be forced into a tight hole at a given pressure, the difference is so small and screening costs are so great, that the advisability of screening is problematical. Increasing the pumping pressure a few pounds apparently more than compensates for any slight disadvantage in the use of unscreened cement.

Experience seems to indicate that the amount of cement that can be injected into a given hole is dependent upon the character of the rock penetrated, the pressure applied, the rate of pumping, and the water-cement ratio.

The character of the rock is not constant for a given hole, and more grout can be forced into a badly broken formation than into one that has been undisturbed. Most cracks and crevices in broken ground are partially filled with gouge or other material deposited by infiltration. Some of this is soluble in water, but acts as an almost perfect grout stop, as the mixing water of the grout is often already carrying its full capacity of suspended matter. The injection of water at high velocity preliminary to grouting opens up passages through this gouge by carrying it to cavities at a greater distance from the hole, thus increasing the grouting radius.

When grout under high pressure comes into contact with dry rock, the rock absorbs a considerable amount of the mixing water. This action takes place more rapidly as the pressure increases. As a result, at the first constriction of the grout channel, the mixing water is forced into the rock while the cement remains within the channel, thus effectively blocking it and marking the grouting radius of that hole. Therefore the initial injections into all high-pressure holes were of plain water or thin grout mixtures.

HIGH PRESSURES AN IMPORTANT FACTOR

The flow of grout through cracks and fissures in the rock is comparable to the flow of liquids through pipes. The frictional resistance of hairlike cracks is very high and must be overcome by the application of pressure. It would seem that the higher the permissible pumping pressure, the greater would be the effective grouting radius, and the fewer the holes that would be required for a given schedule.

TABLE II. SACKS OF CEMENT USED IN GROUTING PARTS ADJACENT TO TUNNELS

Area	Placed	Waste	Total
3 high-pressure rings under dam abutment, Tunnel No. 2	5,343	142	5,485
5 high-pressure rings under dam abutment, Tunnel No. 3	4,319	168	4,487
239 high-pressure holes above plug, Tunnel No. 4	12,615	222	12,837
Totals	22,277	532	22,809

Thick grout having a water-cement ratio of 0.75± by volume was injected at 100 lb per sq in. to fill known voids in the invert of the diversion tunnels where the contractor had installed gravel drains as aids in placing the lining, and in the arch where it was not always possible to fill the form completely at the crown.

Thinner grout, having a water-cement ratio of from 1.0 to 7.0, was injected into the deeper holes, those from 24 to 170 ft in depth. Higher pressures (300 to 750 lb per sq in.) were used in order to consolidate the surrounding rock.

The ability of water to carry suspended matter is dependent upon its velocity. Since the passages through

FIG. 1. GENERAL PLAN OF BOULDER DAM DIVERSION TUNNELS, SHOWING GROUTING AND DRAINAGE SYSTEM

which the grout flows are of variable cross-section, the velocities vary. As a result, there is a tendency for the size of a given channel to be reduced by sedimentation until it is uniformly of the same diameter as the smallest section of the original passage. It was found that this action could be delayed—and consequently more grout injected—by maintaining a reasonably high pumping speed. The pumping pressure was maintained constant, and the pump speed was varied by increasing or decreasing the water-cement ratio as required.

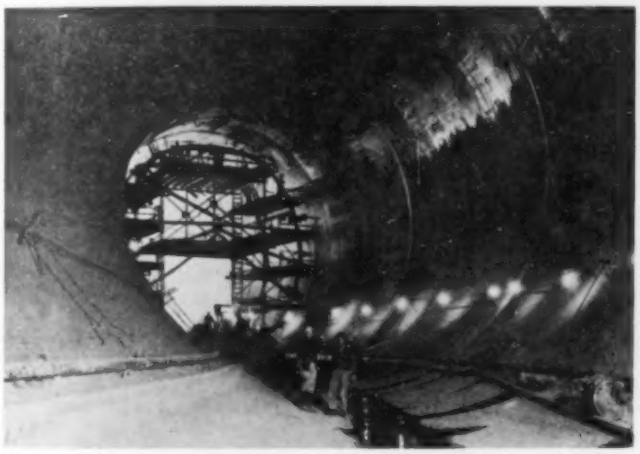
TABLE III. LOW-PRESSURE GROUTING

Tunnel No.	Length	Sq Ft of Rock Area	Cu Ft Total Low-Pressure Grout	Cu Ft Grout per Sq Ft Rock Area
1	3,911	688,000	23,250	0.0338
2	3,417	601,000	27,460	0.0456
3	3,123	549,000	21,274	0.0388
4	3,815	671,000	28,379	0.0423
All tunnels	14,266	2,509,000	100,363	0.0400

Note: Table III does not include the tunnel plug sections, uses the full tunnel circumference (56 ft in diameter) for the rock area, and includes both low-pressure grouting at points of overbreakage and at regular intervals.

Close control of the rate of pumping was found necessary, as a sudden increase in either speed or pressure frequently resulted in the hole's refusing grout shortly thereafter. A pumpman can plug tight (unprofitable) holes by opening and closing the pump by-pass valve in such a way as to cause water hammer.

As measured by volume, the water-cement ratios varied from 7.0 to 0.55. The selection of grout having a proper water-cement ratio is the most difficult phase of high-pressure grouting. Undoubtedly more holes are lost by



DRILLING AND GROUTING JUMBO AT UPPER PORTAL, TUNNEL NO. 4

inexperienced men attempting to use a thicker grout than the hole will accommodate than from any other single cause. On the other hand, if grout is too thin it not only is of inferior quality, but the cavities may be largely filled with water.

GROUTING PROCEDURE OUTLINED

While the procedure varied somewhat according to the different schedules, in general the methods used were as follows:

1. High-pressure holes that had been percussion-drilled were thoroughly cleaned with air and water.
2. High-pressure holes were flushed by pumping water for not more than five minutes to the full capacity of the pump, or to the required grouting pressure.
3. Grouting was begun with initial injections of grout having a water-cement ratio equal to 0.01 S, where S is the required stalling pressure.
4. Data were tabulated at regular intervals of time, as shown in Table VI.

From this information, the water-cement ratio was gradually reduced to the thickest grout that the hole

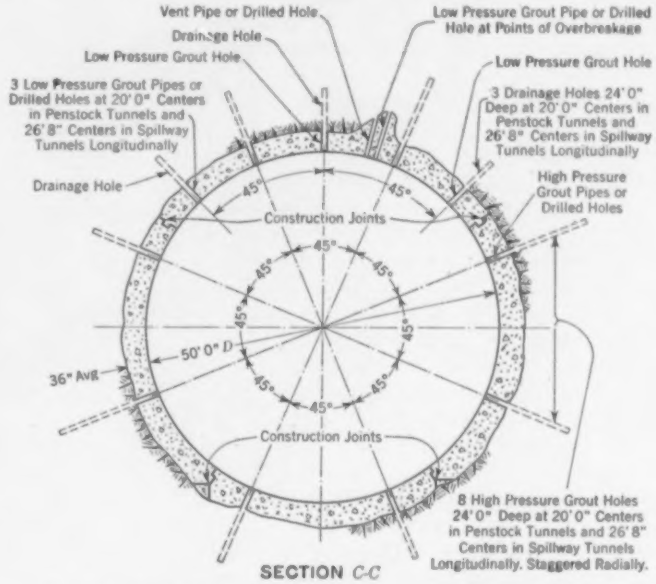


FIG. 2. TYPICAL SECTION THROUGH TUNNELS SHOWING HOLES FOR LOW- AND HIGH-PRESSURE GROUTING AND FOR DRAINAGE

would consistently take. An effort was made to inject the maximum number of sacks of cement per hour. When this rate, which usually follows a descending curve for a given water-cement ratio, had fallen to where the hole was approaching refusal, water was injected for five minutes. This procedure, which almost invariably caused the pumping speed to increase until the thicker grout could again be injected, was repeated with gradually increasing water-cement ratios until the hole refused 0.01 S grout at the required pressure.

TABLE IV. HIGH-PRESSURE GROUTING

Tunnel No.	Lin Ft of Holes	Cu Ft Grout	Cu Ft Grout per Lin Ft of Hole
1	30,037	15,224	0.507
2	14,453	10,496	0.726
3	15,411	4,617	0.300
4	33,376	24,027	0.720
All tunnels	93,277	54,364	0.583

The criterion used for fixing a condition of refusal was that grouting of a given hole should continue until that hole refused to take more than 1 cu ft of grout at the given pressure in 10 minutes. The contractor elected to meet this requirement by using a normal pumping pressure one-quarter to one-half greater than the required pressure. The standing or stalling pressure was taken occasionally, and when this was equal to or greater than

TABLE V. GROUT-HOLE DRILLING

Tunnel No.	Low-Pressure Holes		High-Pressure Holes		Total	
	Number	Lin Ft	Number	Lin Ft	Number	Lin Ft
1	1,273	5,187	1,255	30,037	2,528	35,224
2	1,173	4,597	603	14,453	1,776	19,050
3	1,151	4,478	643	15,411	1,794	19,889
4	1,360	5,047	1,429	33,814	2,789	38,861
All tunnels	4,957	19,309	3,930	93,715	8,887	113,024

the required pressure, the hole was accepted as being completed.

In Table VI is shown the behavior of a typical "free" hole under ideal conditions. The personal equation is

important and should be taken into consideration in interpreting results. There was ample air; the hole was undamaged; the work was done by the contractor's strongest crew; and the inspector directing the work was the most experienced on the job.

The following day shift was handicapped by a varying air supply and by an inspector who was not fully seasoned. The swing shift had a satisfactory air supply but an inexperienced inspector, and no attempt at intelligent grouting was made. The leak which caused abandonment of the hole probably developed about an hour and a half before it was discovered.

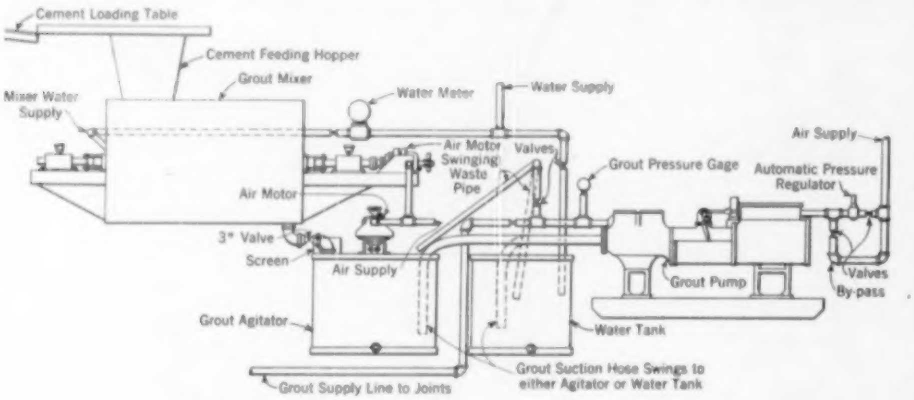


FIG. 3. SCHEMATIC LAYOUT OF PLANT FOR MIXING AND PLACING GROUT

IMPORTANCE OF STOPPING LEAKS QUICKLY

For effective and economical grouting, leaks must be stopped with minimum delay, for once a hole is connected it must be brought to the designed pressure or lost. Delays are paid for in wasted cement and lowered grouting efficiency. Grout channels within the rock contain numerous traps or sags, and when once grout has become hardened in these, the possibility of filling the fissure is forever lost. Subsequent drilling of additional holes in an attempt to fill the area supposed to be infected is a makeshift of doubtful value, and has rarely proved successful.

Discontinuing pumping altogether, especially during hot weather, frequently results in the loss of the hole. This danger seems to be lessened by pumping at a reduced pressure while the leak is being calked. Adequate equipment, a trained crew, and experienced supervision are necessary for effectual results. Material must be at hand for trying various methods of calking in rapid succession, in case it becomes evident that a given method will not stop the leak.

Leaks in general are due to shrinkage cracks, contraction joints, cold joints, rock fissures, or porous areas. They are more or less routine, may be encountered at any time, and are difficult to seal in the order named. Our ideas on sealing them changed materially from those we held when grouting operations were started. An attempt will be made to sketch briefly the development of present methods.

SHRINKAGE CRACKS CLOSED BY INGENIOUS METHOD

The use of wooden wedges to stop leaks at shrinkage cracks did not prove satisfactory. Since these cracks are usually tortuous and narrow, difficulty was experienced in driving wedges, and it was decided to try lead wool. In order to key the wool into the crack, the crack was widened with a calking tool. In widening the crack, it was found that by breaking off a small wedge of concrete next the crack and driving it in, the leak was often stopped. Welding with a pneumatic calking tool, followed by application of a blend of portland and quick-hardening calcium-aluminate cement, will ordinarily seal most leaks of this sort if the pressure is low.

Wooden wedges measuring 1 by 2 by 6 in. were first used to seal contraction joints. Owing to the circular shape of the tunnel section and the length of the wedges, which were of necessity driven radially, a considerable gap existed between adjacent wedges, through which grout escaped freely. It proved advantageous to drive oakum into the crack with the wedges. A further improvement was made by reducing the size of the wedges to $^1/_2$ by 1 by 3 in. These wedges are made of seasoned white pine. They were driven well into the crack and broken off flush with the surface of the concrete. Pumping was continued slowly until the wedges had swollen firmly into place. When necessary, a second row of wedges was driven on top of the first.

Cold joints are tortuous cracks through which grout escapes at high velocity. Our first method of attack was to wedge tightly against the leaking surface a "plaster" consisting of a 1 by 12-in. plank, one side of which was covered with a thick mat of oakum. The water-cement ratio was reduced to 0.75 and the pump operated so as to give a thin, watery exudate around the plaster, thus eventually sealing the leak after a fashion. This method was not satisfactory. It was too slow, gave results of doubtful value, and often permitted the reopening of a leak when the jumbo against which the plaster was braced had to be moved on to another leak. In an attempt to avoid the use of plaster, dry portland cement was applied to the leaking surface and held in place until the dry cement had absorbed water from the grout within the joint, thickening it and causing it to set more

TABLE VI. INSPECTOR'S RECORD SHOWING GOOD HIGH-PRESSURE GROUTING WORK

Time	Cement				Pressure in Lb		
	Total Sacks	Period Sacks	Sacks per Hr	W/C	Air	Pumping	Stalling
11:30 p.m.	24	24	...	3.0	100	750	350
11:45 p.m.	50	26	104	2.5	100	750	350
12:00 m.	82	32	128	2.0	100	750	350
12:15 a.m.	122	40	160	1.75	100	750	350
12:30 a.m.	154	32	126	1.75	100	750	375
12:45 a.m.	164	30	120	2.0	100	750	350
1:00 a.m.	210	26	104	2.0	100	750	375
1:15 a.m.	220	10	40	5.0	100	750	325
1:30 a.m.	256	36	144	2.0	100	750	350
1:45 a.m.	288	32	128	2.0	100	750	350
2:00 a.m.	316	28	112	2.0	100	750	350
2:15 a.m.	348	32	128	2.0	100	750	350
2:30 a.m.	372	24	96	2.0	100	750	375
2:40 a.m.	...	..	...	....	...	...	...
3:00 a.m.	410	38	114	2.0	100	750	350
3:15 a.m.	432	22	88	2.0	100	750	400
3:30 a.m.	448	16	64	3.0	100	750	400
3:45 a.m.	456	8	32	5.0	100	750	400
3:55 a.m.	...	..	...	....	...	...	...
4:10 a.m.	476	20	80	3.0	100	750	375
4:30 a.m.	490	14	42	5.0	100	750	375
4:45 a.m.	501	11	44	5.0	100	750	375
5:00 a.m.	513	12	48	5.0	100	750	350
5:15 a.m.	532	19	76	3.0	100	750	350
5:30 a.m.	550	18	72	3.0	100	750	350
5:45 a.m.	564	14	56	3.0	100	750	375
6:00 a.m.	576	12	48	3.0	100	750	400
6:15 a.m.	588	12	48	3.0	100	750	400
6:30 a.m.	600	12	72	3.0	100	750	375
6:45 a.m.	622	22	88	3.0	100	750	375

Inspector's remarks: 2:40 a.m., water 5 min., flush pump 5 min.; 3:55 a.m., water and flush pump and line 10 min.; 6:15 a.m., water 5 min.

quickly. This proved to be a decided improvement. Following up the idea, a study was made in the field laboratory of the characteristics of various combinations of portland and quick-hardening calcium-aluminate cement. Results of this study are shown in Tables VII and VIII. These tables are based upon the results of a single set of tests. The data contained in them are tentative only and should be used with caution. Exact proportioning and an intimate mixture are necessary for best results.

A mixture of $2^1/_2$ parts portland to 1 part quick-hardening calcium-aluminate cement was adopted as standard. It was carefully proportioned, thoroughly mixed by numerous screenings, re-sacked, and stored to be used as needed. Field mixing was found unsatisfactory. This mixture takes its final set in about five minutes, depending somewhat upon the temperature. It was used extensively for sealing leaks and for grouting in nipples. For cold joints, a leaking surface was quickly chipped with a pneumatic gun to a depth sufficient to give a suitable key, and a blended cement was applied. A $^3/_4$-in. nipple was inserted into the leak to relieve the pressure during patching. Grout was allowed to leak for perhaps ten minutes, during patching, to allow the patch to harden. The nipple was then capped, and the patch usually held.

PORTABLE GROUTING PLANT, SHOWING WATER METER OVER AGITATOR

EXPOSED ROCK GROUTED BY STAGES

The most satisfactory method of grouting exposed rock is stage grouting, that is, pumping thick grout into shallow holes until it shows on the surface. The pumping is then discontinued. At some later date, a second series of holes is drilled, or the first series deepened and grouted as before. This procedure is repeated, pushing the grout out in ever-widening concentric circles until the area to be grouted is covered. If care is exercised in blowing the partially set grout from the holes the drilling cost need not be excessive. On horizontal surfaces this method is most economical of cement and gives excellent results. However, on inclined surfaces such as those on dam abutments and tunnel portals, the cement loss may be large, due to the inaccessibility and nature of the leaks. Wedges are practically useless, as in most cases they merely diffuse the leak by widening the crack. In general, a blended cement patch, built around a nipple inserted in the crack to drain off the grout while the patch is setting, is the most satisfactory method found here. Occasionally, leaks from deep fissures can be stopped by blowing the dry cement blend into them with a sand-blast gun, but unless the leak is of rich grout, this method will not ordinarily succeed.

Leaks from porous areas, while rarely encountered, are the most difficult to seal. If the area is large and the pressure high, no satisfactory method of treatment is known, and grouting results are doubtful. So much time is consumed in getting the leak under control that when pressure is finally reached, there is always a question whether the hole has not really been lost. It seems probable that if a leak does not respond readily to treatment, the hole should be abandoned and a new hole drilled after the porous area has been chipped and patched, as previously described.

I wish to acknowledge my indebtedness to F. A. Backman, superintendent in charge of grouting operations for the contractor, who, with Grout Foremen Frank Airington, Frank Cronin, and Ronald Jones and their crews, contributed largely to the success of the work.

TABLE VIII. COMPRESSIVE STRENGTH OF VARIOUS BLENDS OF PORTLAND AND QUICK-HARDENING CALCIUM-ALUMINATE CEMENT, IN POUNDS PER SQUARE INCH

% P	% Q	30 Min	1 Hr	2 Hr	5 Hr	10 Hr	24 Hr
80	20	456	456	478	456	540	478
70	30	705	710	718	725	720	772
60	40	352	325	550	675	730	692
50	50	125	125	150	375	650	875

P = portland cement; Q = quick-hardening calcium-aluminate cement; water-cement ratio = 0.666.

The dam is being built by the U. S. Government through the Department of the Interior and directly by the Bureau of Reclamation. The late Elwood Mead, M. Am. Soc. C.E., was commissioner and administrative head of the Bureau of Reclamation. Chief Engineer R. F. Walter, M. Am. Soc. C.E., of the Denver office, is in charge of all construction and designs. Construction Engineer Walker R. Young, M. Am. Soc. C.E., represented the chief engineer on the project. Six Companies, Inc., contractor for the construction of Boulder Dam, power plant, and appurtenant works, is headed by President H. W. Morrison, and work in the field was under the direction of Francis T. Crowe, M. Am. Soc. C.E., general superintendent.

TABLE VII. TIME OF SET OF VARIOUS BLENDS OF PORTLAND AND QUICK-HARDENING CALCIUM-ALUMINATE CEMENT

			W/C = 0.333				W/C = 0.666				W/C = 1.00			
			Initial Set		Final Set		Initial Set		Final Set		Initial Set		Final Set	
Test No.	%P	%Q	Hr	Min	Hr	Min	Hr	Min	Hr	Min	Hr	Min	Hr	Min
1	100	0	4	50	7	15	9	10	13	30	..	..	..	..
2	90	10	2	28	4	50	5	37	10	22	..	..	..	..
3	80	20	0	12	0	19	0	14	1	12	..	..	..	..
4	70	30	0	5	0	7	0	5	0	20	0	9	6	14
5	60	40	0	2	0	5	0	4	0	48	0	6	6	25
6	50	50	0	2	0	3	0	4	6	17	5	5	5	42
7	40	60	0	7	0	10	2	53	5	40	..	..	..	..
8	30	70	0	1	3	8	3	18	7	57	4	53	8	33
9	20	80	0	2	4	8	3	50	5	18	..	..	..	..
10	10	90	4	52	5	17	5	10	6	50	..	..	..	..
11	0	100	9	18	16	33	8	49	9	19	..	..	..	..

P = portland cement, Q = quick-hardening calcium-aluminate cement; W/C = water-cement ratio by weight.

ENGINEERS' NOTEBOOK

From everyday experience engineers gather a store of knowledge on which they depend for growth as individuals and as a profession. This department, designed to contain ingenious suggestions and practical data from engineers both young and old, should prove helpful in the solution of many troublesome problems.

Chart for Concrete Column Design—1936 Specifications

By Alan Lee Slaton

Junior Assistant Engineer, New York State Department of Public Works, New York, N.Y.

Several changes in the design of reinforced concrete columns are embodied in the new standard building code adopted by the American Concrete Institute on February 25, 1936. Under the new code the gross area of the column, instead of the core area, is considered as resisting compression. The spiral steel is not considered to be effective until the fireproofing area has been removed, and is designed to replace that area. Laterally tied columns are allowed to take 70 per cent of the load permitted spiral columns by the code formula.

The diagram presented here (Fig. 1)

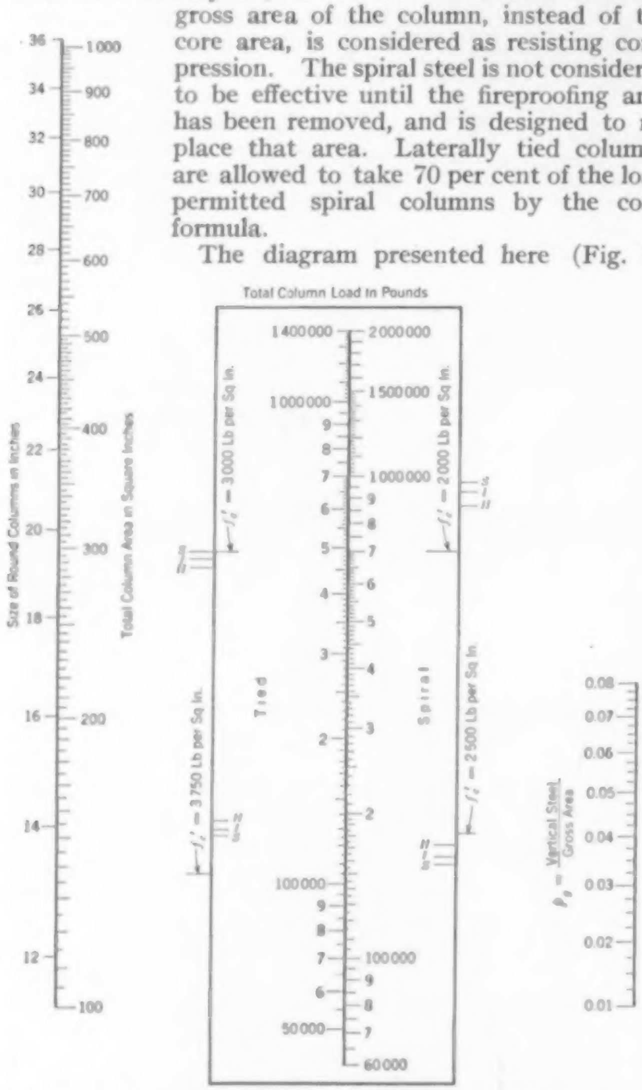


Fig. 1. Chart for Design of Laterally Tied and Spirally Reinforced Columns Under 1936 A.C.I. Code

Match Marks Labeled *S*, *I*, and *H*, Refer Respectively to Structural, Intermediate, and Hard-Grade Reinforcement

should be of value in applying the new specifications. It is based on the formula:

$$P = A_g (0.22 f_c' + f_s p_g)$$

in which P = allowable load

A_g = gross area of column

f_c' = compressive strength of concrete

f_s = nominal working stress in vertical column reinforcement, to be taken at 40 per cent of the minimum specification value of the yield point, that is, 13,200 lb per sq in. for structural grade steel, 16,000 lb per sq in. for intermediate grade steel, and 20,000 lb for rail or hard grade steel

p_g = ratio of the effective cross-sectional area of vertical reinforcement to the gross area, A_g

The chart as here oriented is applicable directly to either spiral or laterally tied columns using 3,000-lb concrete and structural grade reinforcement. However, if the

Table I. Percentage of Spiral Steel Required in Reinforced Concrete Columns with 2-In. Fireproofing

Core Dia.	2,000-Lb Concrete		2,500-Lb Concrete		3,000-Lb Concrete		3,750-Lb Concrete	
Inches	Rods	Wire	Rods	Wire	Rods	Wire	Rods	Wire
8	2.81	1.88	3.52	2.34	4.22	2.81	5.27	3.52
10	2.16	1.44	2.70	1.80	3.24	2.16	4.05	2.70
12	1.76	1.17	2.19	1.46	2.63	1.75	3.29	2.19
14	1.46	0.98	1.83	1.22	2.19	1.46	2.74	1.83
16	1.26	0.84	1.58	1.05	1.89	1.26	2.36	1.58
18	1.13	0.75	1.41	0.94	1.69	1.12	2.11	1.41
20	1.12	0.75	1.24	0.83	1.48	0.99	1.86	1.24
22	1.12	0.75	1.13	0.75	1.35	0.90	1.69	1.13
24	1.12	0.75	1.12	0.75	1.22	0.81	1.52	1.01
26	1.12	0.75	1.12	0.75	1.12	0.75	1.39	0.93
28	1.12	0.75	1.12	0.75	1.12	0.75	1.31	0.87
30	1.12	0.75	1.12	0.75	1.12	0.75	1.22	0.82
32	1.12	0.75	1.12	0.75	1.12	0.75	1.12	0.75

center scale is cut out on the enclosing lines and mounted in slide fashion, the chart can be used for 2,000, 2,500, 3,000, and 3,750-lb concrete and for structural, intermediate, and hard-grade reinforcement in any combination. Fool-proof match marks are provided.

The necessary percentage of spiral reinforcement is given in the new specifications by the formula:

$$p' = 0.45 (R - 1) \frac{f_c'}{f_s'}, \text{ in which}$$

p' = ratio of volume of spiral reinforcement to the volume of the concrete core (out to out of spirals)

R = ratio of gross area to core area of column, A_g/A_c

f_s' = useful limit stress of spiral reinforcement, to be taken as 40,000 lb per sq in. for hot-rolled rods of intermediate grade (A.S.T.M. serial designation A15-35) and 60,000 lb per sq in. for cold-drawn wire (A.S.T.M. serial designation A82-34)

It is further specified that p' shall not be less than 0.0112 for spirals of hot-rolled rods of intermediate grade, or 0.0075 for those of cold-drawn wire. Table I, based on this formula, gives values of p' for the common case of columns with 2-in. fireproofing.

Formulas for Preliminary Design of Semi-Elliptical Sewer

By Harry C. Plummer, Assoc. M. Am. Soc. C.E.

Chief Engineer, Brick Manufacturers Association of America, Cleveland, Ohio

A sewer of semi-elliptical section is highly efficient structurally, since its form coincides closely with the line of resistance of the arch. If the normal sewage flow is in the neighborhood of one-third the maximum flow, this section is also efficient hydraulically and may frequently be used to advantage. A section of this type, designed by the engineers of the Sanitary District of Chicago, is shown in Fig. 1, and its hydraulic properties are given in Fig. 2.

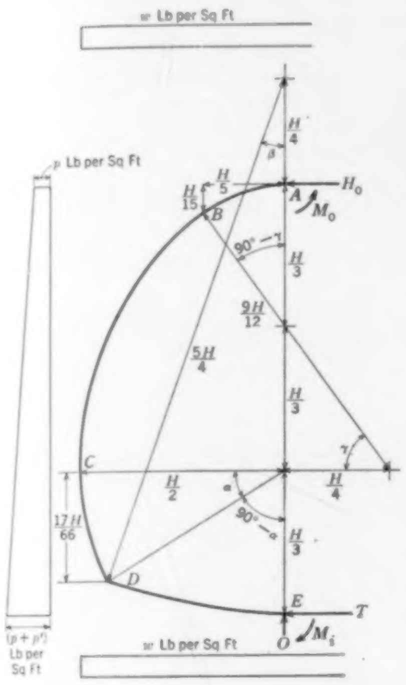


Fig. 1. Semi-Elliptical Sewer Section

In the following paragraphs, formulas are developed to aid in the preliminary structural design of sewers conforming to this section. They are applicable both to reinforced brick masonry and to reinforced concrete, and the results will be found to check closely with those obtained from an analysis of the final design.

The sewer is assumed to be symmetrically loaded, and the half section is considered as a curved beam acted upon by the external loads and by thrust and moment at the crown and at the center of the invert. Since the loading is symmetrical, the shears at these points are zero. The vertical and horizontal components of the earth pressure are assumed to be distributed, in the manner shown in Fig. 1, over the horizontal and vertical projections of the center line of the sewer ring. This is a slight approximation, since in the final analysis they are assumed to be distributed over the horizontal and vertical projections of the extrados. The approximate assumption is also made that the moment of inertia of the sewer wall is constant; this is exactly true only if the wall thickness is uniform throughout.

Taking the point E as origin, integral expressions can now be written giving the relative horizontal deflection, and the relative change in slope of the tangent, at the crown and the center of the invert. Both of these expressions must equal zero because of the symmetry of structure and loading. They are:

$$\int_E^A \frac{M'ds}{EI} = 0, \text{ and} \int_E^A \frac{M'y\,ds}{EI} = 0$$

in which M' is the bending moment at any point.

Assuming the moment of inertia as constant, EI may be dropped from both equations. Now, using the nomenclature of Fig. 1, M' may be expressed in terms of

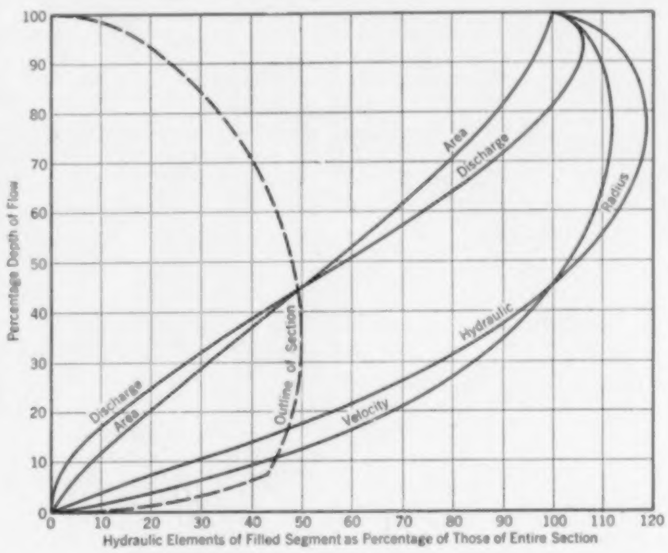


Fig. 2. Hydraulic Elements of Semi-Elliptical Section

$n = 0.014$; $s = 0.0004$; $H = 10.0$ ft; $A = 0.7992H^2$; $R = 0.2470H$. Detailed Dimensions Are Shown in Fig. 1.

M_i, T, H, w, p, p', and x and y, a separate expression being written for each of the four segments ED, DC, CB, and BA. For example, in the segment ED,

$$M' = M_i + Ty - \frac{wx^2}{2} - \frac{(p + p')y^2}{2} + \left(\frac{p'}{H}\right)\left(\frac{y^3}{6}\right)$$

Moments which produce compression in the intrados of the sewer are considered as positive.

These expressions must now be transformed to polar coordinates. Again referring for example to the segment ED, $x = \frac{5H}{4}\sin\theta$, $y = \frac{5H}{4}(1 - \cos\theta)$, and the limits of θ are 0 and β. Substituting the transformed values for M' in the integral equations, and remembering that ds equals $\rho d\theta$, we obtain expressions involving the one variable θ, which may be integrated and solved simultaneously for M_i and T, the moment and thrust at the center of the invert:

$$\begin{aligned} M_i &= 0.0741wH^2 - 0.0495pH^2 - 0.0293p'H^2 \\ T &= -0.0222wH + 0.477pH + 0.332p'H \end{aligned}$$

Here H is in feet; p, p', and w are in pounds per square foot; and M_i and T are in pound-feet and pounds, respectively, per linear foot of sewer.

Moments at points A, B, C, and D on the arch may be obtained from the general moment equation, $M = M_i + Ty + m$, where m is the moment due to external forces between the origin and the point about which moments are taken, and is opposite in sign to M_i:

$$\begin{aligned} M_D &= -0.0194wH^2 - 0.0162pH^2 - 0.0069p'H^2 \\ M_C &= -0.0583wH^2 + 0.0539pH^2 + 0.0320p'H^2 \\ M_B &= +0.0334wH^2 - 0.0396pH^2 - 0.0199p'H^2 \\ M_A &= +0.0519wH^2 - 0.0725pH^2 - 0.0306p'H^2 \end{aligned}$$

As an example of the application of these formulas, let it be required to design the sewer ring for the sec-

tion shown in Fig. 3. Presume that the depth from the surface of the ground to the crown of the sewer is 24.4 ft, and the weight of the backfill is 100 lb per cu ft. The horizontal pressure will be taken as one-third the vertical.

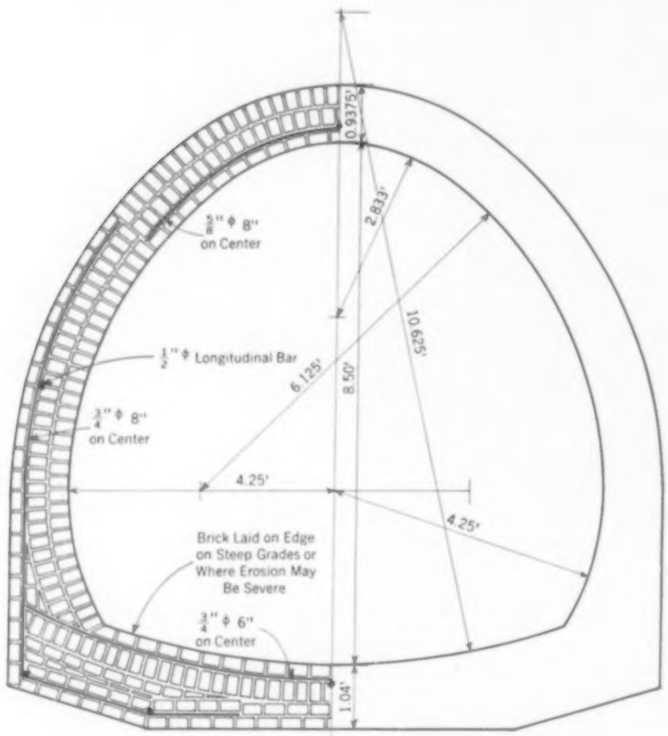


FIG. 3. PRELIMINARY DESIGN BASED ON APPROXIMATE FORMULAS

Marston's formula for vertical pressure is $W = cw_1B^2$, in which W is the total load per linear foot of sewer; w_1, the weight of backfill in pounds per cubic feet; B, the width of the trench a little below the top of the pipe; and c, a coefficient depending upon the ratio of depth to width of trench and the character and condition of the backfill. In this example B may be taken as 10.8 ft and c as 1.70, giving a value of 19,850 lb for W. w = 1,840 lb per sq ft, and $p = \frac{W}{3}$ = 610 lb per sq ft. On account of the depth of the sewer and the consequent relatively high values for w and p, the weight of the masonry can be disregarded and the horizontal pressure can be assumed to be distributed uniformly over the vertical projection of the sewer, thus making p' equal to zero. The inside diameter of the sewer is 8.5 ft, and assuming a 1-ft thickness for the ring, H = 9.5 ft.

On these assumptions the numerical values for moment and thrust at the crown are computed to be 4,630 lb-ft and 4,006 lb, respectively. A similar investigation for moment should be made at points B, C, D, and E.

The preliminary design of the ring, as shown in Fig. 3, follows from a consideration of these values. A more precise analysis of this structure has been made, and the moments and thrusts thus determined are in close agreement with those obtained from the general formulas.

The maximum stresses (in pounds per square inch) developed in the section, due to combined compression and bending, are:

	MASONRY	STEEL
Crown	488	11,700
Haunch	490	6,850
Invert	755	17,150

If the steel in the crown and haunch is reduced and the sewer is reinforced with $^5/_8$-in. bars on 12-in. centers, the maximum stresses are:

	MASONRY	STEEL
Crown	550	16,700
Haunch	675	14,600

Concreting Operations on the Moffat Water Tunnel

By GEORGE R. BARLOW

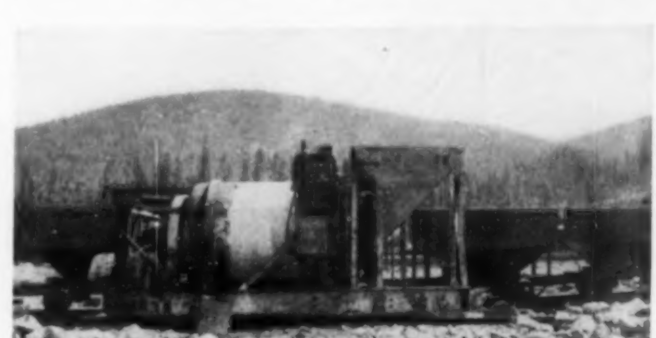
PROGRESS ENGINEER, UTAH-BECHTEL-MORRISON-KAISER COMPANY, DENVER, COLO.

WHEN the Moffat railroad tunnel was completed in 1927, the City of Denver obtained a lease on the "pioneer bore" with the object of converting it into a water tunnel for a transmountain diversion. The diversion project is now under way, and the preparation of the tunnel for its new purpose is one of its interesting features.

Water is to be diverted from the Fraser River some distance upstream and conveyed by canal and siphon to a shaft near West Portal (Fig. 1), whence it enters the tunnel under sufficient head to force it over the apex. Water from other streams is to be introduced, also under pressure, into the adit tunnel at West Portal itself. The high pressure to which the west half of the bore will thus be subjected, coupled with the nature of the ground through which the tunnel passes, makes necessary a lining of heavily reinforced concrete throughout the entire pressure section.

The contract for enlarging and lining the 16,000 ft of tunnel and shaft was let to the Utah-Bechtel-Morrison-Kaiser Company early in the spring of 1935, and the work in the shaft and main tunnel was completed June 10, 1936. The shaft was lined with steel plate concreted to the rock. The adit tunnel, with an inside diameter of 68 in. was similarly treated and was completed late in September 1936.

Because of the rigorous winters and the enormous snowfall at West Portal—25 ft of snow fell during the



Photograph by R. E. Van Liew, Junior Correspondent for "Civil Engineering"

PNEUMATIC PLACER USED IN THE MOFFAT WATER TUNNEL

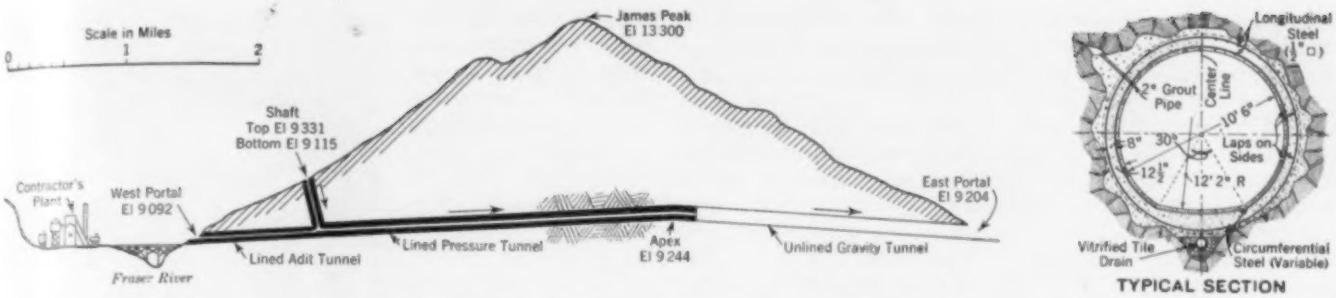
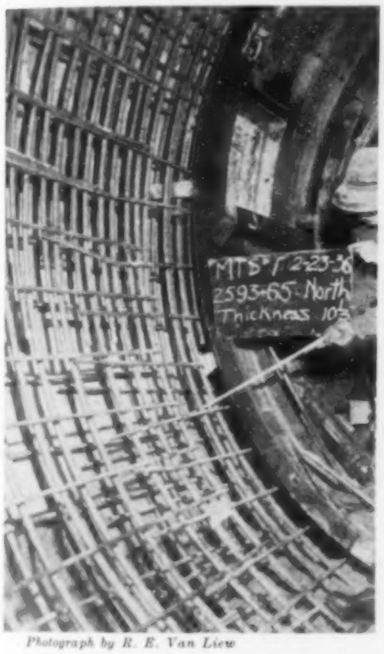


FIG. 1. THE PIONEER BORE OF THE MOFFAT RAILROAD TUNNEL, AS MODIFIED FOR DENVER TRANSMOUNTAIN WATER DIVERSION

past season—elaborate precautions had to be taken to prevent interruptions in the concreting operation. The sides and bottoms of the gondola cars that brought the aggregate from Granby, 22 miles away, were equipped with steam pipes, and as the cars arrived at the site they were run into a shed and hooked up to live steam from boilers. It often took eight hours to thaw the material, even though the shed itself was kept quite warm by coal stoves. After thawing, the aggregate was dumped through a grill (to remove any incidental oversized material) into a hopper, and transported by bucket conveyor to the bunkers. The railroad furnished a locomotive to switch cars and to keep a supply of aggregate on hand, but the weather was so severe on some occasions that it was unable to maintain a schedule and thus storage facilities had to be large enough to continue the pour. Bulk cement was delivered in box cars, unloaded in a separate shed into a hopper, and carried by conveyor to a steel bin with a capacity of about 300,000 lb. Reinforcing steel, delivered on flat cars, was unloaded in a third shed by a 20-ton hoist mounted to roll along and across the building. Space to store 10 carloads of steel was within reach of the hoist.



Photograph by R. E. Van Liew

A DOUBLE CURTAIN OF HEAVY CIRCUMFERENTIAL BARS WAS REQUIRED

Proportioning of concrete materials was by weight. Because of the necessity of obtaining as high strength concrete as possible, a comparatively rich mix was used, consisting of 775 lb of cement, 1,310 lb of sand, 1,890 lb of gravel, and 13 lb of lime per batch. The aggregate bunkers and concrete bin fed directly into the batching hopper, and scales equipped with a photoelectric device shut off the flow of each material when the correct amount had been released. After batching, the materials were discharged to a 28-S, tilting-type mixer, and mixed dry for 1 min. Bottom-dump cars running on track of 24-in. gage conveyed the dry mix to the tunnel. Each car held two 1.1-cu yd batches, in separate compartments. They were operated in trains of five by 4-ton electric locomotives.

At the pouring point, the cars were run up onto a passing track and the batches were dumped, one at a time, onto a conveyor feeding directly into a pneumatic placer (Fig. 2). The latter piece of equipment consisted mainly of a rotary mixer arranged to discharge the concrete, under air pressure, through a 5-in. pipe, 200 ft in length, leading to the top of the forms. Air for this operation was supplied at a pressure of 100 lb per sq in. from the plant at West Portal. Water was metered into the mixer along with the charge, and mixing was continued for 1 min 20 sec.

This type of pouring arrangement was used not only because of freezing temperatures, but because it allowed the contractor to hold the dry mix on the track for a period up to two hours in case of an unexpected delay. The whole outfit—passing track, mixer, air receiver, and water tank—traveled on rails and backed up as the pouring progressed. The entire ring was poured in one operation.

Owing to the necessity of finishing the main tunnel by June to obtain as much of this year's runoff as possible, and to the very slight changes of temperature to which the lining will be subjected, it was decided to use a continuous type of pour, thus eliminating the delays which accompany the use of a vertical joint every few feet. Collapsible steel forms of the horseshoe type were used. They came in 15-ft sections and were moved through one another on a jumbo that traveled on rails in the forms

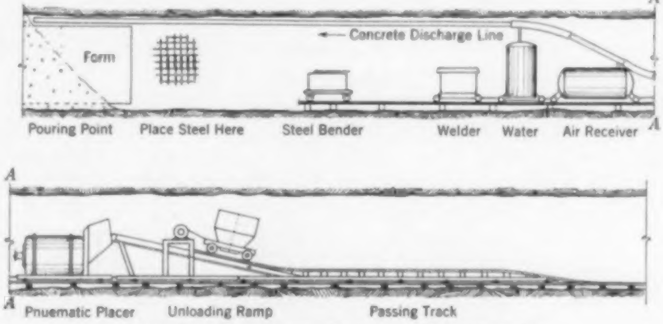


FIG. 2. CONCRETE PLACING EQUIPMENT

themselves. Sixteen sections—240 ft—of forms were enough to permit continuous pouring in the large tunnel. After the forms were removed, the green concrete was kept wet for several days, and then any defects that appeared were chipped and patched.

Because of the pressure to which the tunnel lining is subjected, grout pipes were placed during the pouring in timbered sections and at other points where it appeared a void might be left. The pipes were later connected, one at a time, to a line pump, and grout was forced in from a tank, fed from mixing cans, until a pressure of

100 lb per sq in. had been reached. This was considered sufficient evidence that the hole was completely grouted. The mix used in the grouting was 3 parts cement, 5 parts sand, and 3 parts water.

The general arrangement of the reinforcing is shown in Fig. 1. The varying types of ground along the tunnel line made it advisable to vary the size and spacing of the circumferential bars at frequent intervals; in some sections $^1/_2$-in. round bars were adequate, while in others bars as large as 1-in. square were required. The average spacing was about 7 in. In order to eliminate the trouble usually encountered with bottom supports when the inner curtain of steel is close to the forms, the reinforcement was held in position by wires hung from the arch of the tunnel and by steel dowels in the rock along the sides. In the adit tunnel the circumferential reinforcement was spiraled from $^7/_8$-in. bars, 60 ft long.

With a concrete crew averaging 55 men per shift, the average pour of concrete was 225 cu yd for 125 ft of tunnel per 24 hours. The high was 450 cu yd for a distance of 225 lin ft. The equipment was capable of pouring much faster, but the steel placing was necessarily a slow process. Even with a crew of 25 steel men per shift, it was often impossible to pour concrete during more than two shifts per day. The steel men were able to place 40 tons of the heavier sizes in 24 hours.

For the Board of Water Commissioners of the City and County of Denver, O. M. Strange and J. B. Banner were field engineer and assistant, respectively, and for the contractor, J. T. Powell has been superintendent.

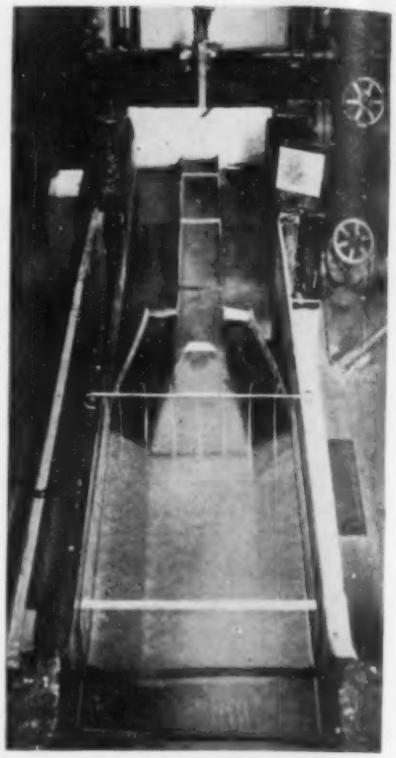
Model Tests of Outlet Transitions

By MONS H. BENSON, JUN. AM. SOC. C.E.

DESIGN DEPARTMENT, TENNESSEE VALLEY AUTHORITY, KNOXVILLE, TENN.

THE function of an outlet transition is to transfer swiftly moving water from a flume or siphon to a larger channel, usually of earth, in which the velocity is low. The transition should provide a good distribution of velocity in the lower channel and recover as much velocity head as possible. This is best accomplished when the water passes through the transition evenly and smoothly, without sudden breaks in the surface, or concentration of high velocity in part of the transition with slack water in the remainder. The experiments described in the following paragraphs were made to study the flow through a carefully designed warped transition, and to develop, if possible, a satisfactory transition that would be simpler and cheaper to construct.

The general set-up for the experiments is shown in Fig. 1. A continuous flow of 0.35 cu ft per sec was maintained for all runs. The velocity through the headgate was higher than critical, but a hydraulic jump occurred in the flume; consequently all velocities through the transition were below critical. A velocity of 2.5 ft per sec was maintained in the flume, filling it to a depth of 4 in. For a scale ratio of 1 to 36, this velocity would be equivalent to 15 ft per sec in the prototype. The width of the channel was made 18 in. and the depth kept at 4 in., allowing an average velocity of 0.9 ft per sec in the model or 5.4 ft per sec in the prototype. This is higher than allowable in practice for unlined channels, but is the best obtainable in this channel.



WING WALLS IMPROVED VELOCITY DISTRIBUTION IN WARPED TRANSITION
The Relative Deflections of the Wires Suspended from the Bar Provided an Easy Means for Comparing Velocities Across the Channel

A simple but effective device for indicating the distribution of velocity at the transition outlet was made by hanging seven straight wires loosely looped about a round rod which rested on the walls of the channel. The wires were spaced 0.2 ft apart and hung so that they just cleared the channel bottom. The angle each wire made with the surface of the flowing water gave an excellent comparison of the way the velocities varied in the cross section.

General dimensions of the warped transition are also shown in Fig. 1. During the test runs the indicator showed clearly that the velocity distribution in the channel was not uniform across the outlet. A high velocity was always found at one side, while at the other there was very little movement. At the side opposite to the main current the water actually flowed backwards up the transition to the flume, as indicated by the path of a weighted float shown in Fig. 2.

The side to which the main current was attracted seemed to be a matter of chance; both sides were alternately so favored. In the flume, although scarcely noticeable, the current seemed to deflect from one side to the other as it flowed downstream, this tendency being carried across the transition into the slower water beyond. The phase of this weaving path was affected by the position of the hydraulic jump, and could also be altered by inserting a short metal plate at an angle to the side of the flume wall.

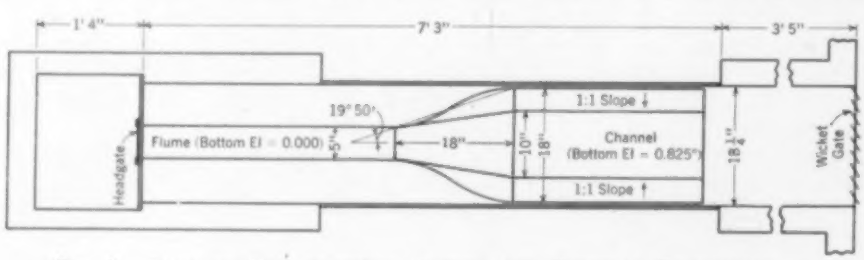


FIG. 1. PLAN OF EXPERIMENTAL FLUME, AND GENERAL DIMENSIONS OF WARPED TRANSITION

In the next step of the investigation, two wing walls made of tin were placed in the transition, as shown in an accompanying illustration. The upstream edges of the walls were separated a distance of one-third the width of the water section. With this device in place the flow in the channel below the transition was smooth and well distributed. There was a slight eddying around the downstream edges, but

not a serious amount. In an actual transition, such walls would probably form an undesirable obstruction for catching floating material and debris. However, they indicated the effectiveness of using some device for spreading the flow, and on this basis a new transition was designed. Construction was simplified by

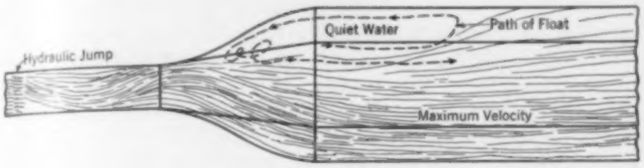


FIG. 2. TYPICAL STREAM LINES, SHOWING UNEVEN DISTRIBUTION OF VELOCITIES

making the sides vertical planes instead of warped surfaces. The transition was also shortened considerably by setting the sides at an angle of about 45 deg with the flume. Details are shown in Fig. 3(*a*). The next problem was to determine the most effective size and shape of baffle pier to spread the flow. Wax models of various shapes were prepared and tested, and fairly satisfactory results were obtained with several forms. The one that gave the most consistent and stable performance is shown in Fig. 3(*b*), with its dimensions in terms of *D*, the depth of flow in the channel, and *T*, the surface width. The stream lines produced by this arrangement are shown in Fig. 3(*c*).

With the pier not in place, it was possible to change the current from one side of the channel to the other by changing the flow conditions in the flume several feet above the transition. This was done by deflecting the current against the sides with a sheet of tin. After the pier was placed in the transition, the effect of changed entrance conditions was greatly diminished, and the flow returned completely to normal as soon as the piece of tin was removed.

The results obtained from this small experiment indicate that further work along this line on larger models would be justified. I do not wish to imply that all

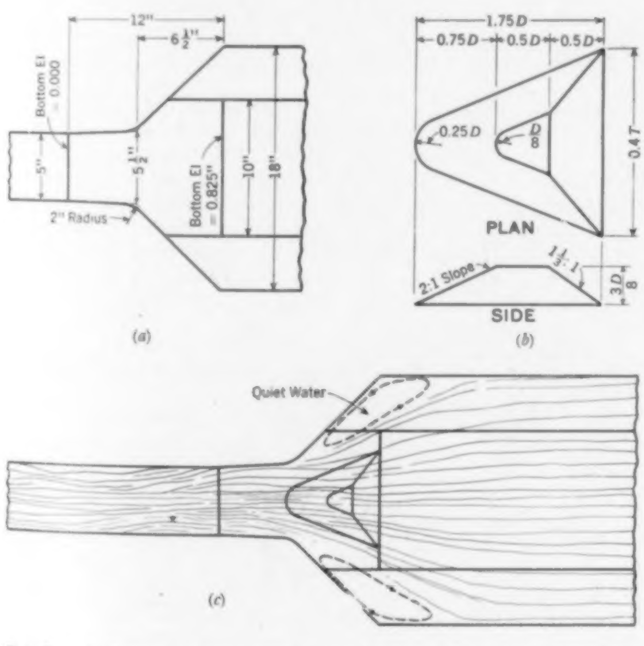


FIG. 3. A SHORT TRANSITION, WITH BAFFLE PIER AND VERTICAL SIDE WALLS

warped transitions give undesirable results. Many such outlets have been built, and when made of sufficient length and with adequate canal lining downstream, have operated satisfactorily and without harmful scouring of the earth section. Further, the flume velocity in the present experiment is nearer to critical than is ordinarily found in practice, and tends to aggravate the conditions in the transition. However, while the carefully designed warped transition provides a smooth surface over which the water will flow if the conditions are such that it is forced to do so, it cannot be said that the warped surface itself is a guarantee of good operation. A submerged baffle pier in the transition affords better control, and more assurance that velocities in all parts of the downstream section are reduced sufficiently to prevent scour.

A pier like that described here, made of concrete, would be rugged and durable, and could be installed easily in an existing transition. In cases where undesirable scouring occurs, such an addition might be an effective remedy.

These experiments were performed by the writer at the University of Michigan in 1932, and were used as a basis for a thesis in partial fulfillment of the requirements for the degree of master of science in engineering.

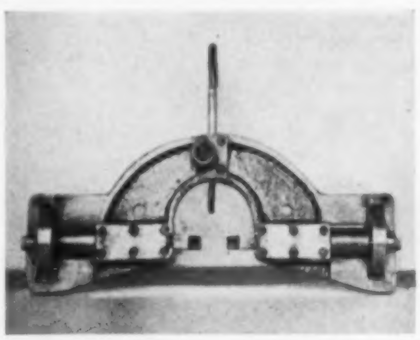
A Device for Precise Measurements of Orifice Discharge

By S. FRANZ YASINES, ASSOC. M. AM. SOC. C.E.

INSTRUCTOR IN CIVIL ENGINEERING, NEW YORK UNIVERSITY, NEW YORK, N.Y.

THE usual method of calibrating orifices consists primarily of measuring the actual rate of discharge by means of a tank and a weighing scale, or a volumetrically calibrated tank. This method, however, fails to give satisfactory results if the capacity of the tank or of the weighing scale is insufficient to measure a large quantity of fluid. Inaccuracies may be caused both by the shortness of the observation period and by the variation in the effect of jet impact, between the beginning and the end of the run, on the gage reading or the observed weight.

A different method of calibration, which avoids these difficulties, is suggested by the fact that the coefficient of discharge is the product of two other independent factors—the coefficient of velocity and the coefficient of contraction. The only pieces of equipment necessary in the second method are (1) a Pitot tube to determine the coefficient of velocity, and (2) a device to measure accurately the diameter of the contracted section of the jet in order to compute the coefficient of contraction.



ALL MEASUREMENTS NECESSARY FOR COMPUTING ORIFICE DISCHARGE CAN BE MADE WITH THIS EQUIPMENT

Both of these devices are incorporated in the apparatus shown in an accompanying photograph. It was designed by the writer and has been used by him in experimental and research work on standard and bevel-edged cir-

cular orifices. It proved particularly useful in studying the effect of different bevel angles on contraction of the jets and rate of discharge.

The instrument is made of brass. It consists essentially of a semicircular base plate on which are mounted two independently operated micrometers and a Pitot tube. Two $^3/_8$ by $^3/_8$-in. brass rods, beveled at the ends to form straight edges in the plane of the orifice are used to measure the diameter of the contracted section of the jet. These edges are brought tangentially to the cross-section of the jet by means of micrometer screws whose least count is one one-thousandth of an inch. The micrometer scales are so adjusted that when the edges are brought together the sum of the two readings is zero. In operation, the apparatus is held in position by bolts passing through holes in the base plate, and the distance between the plane of the straight edges and the plane of the orifice may be varied by means of washers.

The Pitot tube is set perpendicular to the axis of the micrometers, and is equipped with a rack and pinion by which it can be slid into and out of the jet. The outlet end of the tube may be connected by rubber tubing to any pressure-measuring gage.

The accuracy with which the necessary coefficient can be obtained with this instrument increases as the size of the orifice increases. For example, the discharge coefficient obtained by this method on a 1-in. circular orifice may vary by less than 2 per cent from the values obtained in a carefully conducted volumetric calibration.

Our Readers Say—

In Comment on Papers, Society Affairs, and Related Professional Interests

Malaria Mosquitoes Long Present in the Rio Grande Valley

DEAR SIR: I should like to call attention to a misstatement in the article on "Malaria—A Challenge to Engineers" by J. A. LePrince, in the July issue. On page 447 of the article in question Mr. LePrince states: "What should be of most interest to civil engineers in regard to the distribution of this disease (malaria) is that in New Mexico, and in the low-rainfall areas of some other states, where malaria has been unknown for the past fifty years, it is now fairly well established and on the increase by leaps and bounds. And every bit of it in such localities has been built into existence unwittingly by the engineering profession."

From 1919 to 1923 I was chief of the Division of Sanitary Engineering in the New Mexico State Department of Health and had occasion to become quite familiar with the existence of malaria and *Anopheles* in New Mexico. I was surprised to find areas of endemic malaria in New Mexico, at various points along the Rio Grande. At Española, in the upper part of the valley north of Santa Fe, there was malaria which had evidently been present for a long period, and *Anopheles* were breeding profusely under the native system of irrigation. Malaria had also been endemic for a long time in Mesilla Valley in Doña Ana County, especially in the area along the Rio Grande in a northerly direction from Las Cruces. After the introduction of irrigation by means of the Elephant Butte Dam, malaria increased, but it had undoubtedly been present before the introduction of irrigation by the U. S. Bureau of Reclamation.

Without refreshing my memory by examination of old reports on file in Santa Fe, I cannot positively state that malaria was absent from the remainder of the Rio Grande Valley in New Mexico, but it is my recollection that comparatively few *Anopheles* and practically no malaria occurred in the Rio Grande Valley between the upper end of Elephant Butte Reservoir and the lower end of Española Valley. It is also my recollection that I found a few *Anopheles* at Hot Springs, a very few at San Marciel, and a very few at Belen and Isleta. Native irrigation had been practiced at Belen and Isleta probably for centuries, but the *Anophelines* were rare. The *Culicines* were abundant.

One interesting feature in connection with the endemicity of malaria at Española was the high altitude of the Española Valley. My recollection is that this area has an elevation of about 5,600 ft.

HAROLD F. GRAY, M. Am. Soc. C.E.
Sanitary and Hydraulic Engineer

Berkeley, Calif.
September 20, 1936

Engineers Need Information About Mosquito Species

TO THE EDITOR: As pointed out by Harold F. Gray, M. Am. Soc. C.E., in his article on "Control of Pest Mosquitoes for Comfort," in the October issue, mosquitoes have for centuries been a source of annoyance to man. They have limited, and still limit, his occupation of many regions of the globe. They are the direct cause of two particularly important diseases of the tropical and subtropical regions of the world—malaria and yellow fever. They are often present in both seashore and mountain resorts, in the vicinity of large cities, and in the mining camps of the far North. They are likewise extremely abundant in the many irrigated regions of the United States.

The engineer owes it to his profession as well as to his own reputation to be so informed that he will not unwittingly be the means of providing new breeding grounds. Sometime in his career he will more than likely be involved in the construction of railways, highways, water-power developments, drainage projects, or industrial enterprises. In such construction he can avoid the creation of breeding areas only by being informed and by practicing what he knows.

Different species of mosquitoes differ in breeding habits, and in order to take effective control measures it is necessary to know what species is causing the trouble. It would be ridiculous to attempt to eliminate a mosquito problem within a city by draining nearby marshes if the insects that were causing the trouble belonged to the genus *Culex*, since these mosquitoes breed mainly in artificial receptacles. For example, there are in Oregon at least seven types or associations, of two or three mosquito species each, the habits and control of which are quite different. These may be characterized as follows:

1. The flood-river type includes *Aedes vexans* Meig. and *A. aldrichi* Dyar and Knab. Both of these species lay their eggs during June, July, and August, not upon water but upon the damp soil of areas that are annually flooded by the Columbia and Willamette rivers. The eggs remain on the soil through the winter and hatch when covered by floodwater the following spring.

2. The so-called snow-mosquito type includes *Aedes communis* DeGeer, *A. hexodontus* Dyar, and *A. fitchii* Felt and Young. Mosquitoes of this group, as is the case with the flood-river mosquitoes, lay their eggs on the ground, in depressions, and along the margins of small lakes in mountainous sections of the state. The eggs remain until flooded by snow water early in the spring of the next year.

3. The temporary-rain-pool type includes *Aedes aboriginis* Dyar and *A. fitchii* Felt and Young. These species occur along the

coast range, and their habits are almost identical with those of the two types just described.

4. There is only one species of the salt-marsh type, *Aedes dorsalis* Meig. In contrast with the three types just mentioned, which have but one brood a year, this species has several.

5. The irrigation-water type includes *Aedes flavescens* Muller, *A. dorsalis* Meig., *Culex tarsalis* Coq., *Anopheles maculipennis* Meig., and *A. punctipennis* Say. Most of the *Aedes* have only one brood a year but the *Culex* and *Anopheles* have several.

6. The malaria type includes *Anopheles maculipennis* Meig. and *A. punctipennis* Say. There are only two species of this genus in Oregon. Their eggs are laid singly, directly on permanent bodies of clean water, and there are several broods each season.

7. The artificial-container type includes *Culex pipiens* L., *Theobaldia incidens* Thom., and *T. inornata* Will. To this type may be added *Aedes varipalpus* Coq., which breeds principally in tree holes. The adults lay their eggs on dirty, stagnant water, particularly in catch basins and tin cans. Several broods are produced yearly.

The engineer should realize the importance of this information and know where it can be obtained, as from the entomologists of the state experiment stations or from those of the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture.

H. H. STAGE
Associate Entomologist, U. S. Bureau of Entomology and Plant Quarantine

Portland, Ore.
October 8, 1936

Placing Cofferdam Cribs at Bonneville

TO THE EDITOR: I was interested in the article on "Construction Methods at Bonneville" by C. I. Grimm, M. Am. Soc. C.E., in the October number. The placing of the cribs forming the cofferdams was a key problem in the construction of this project. The cofferdams consist of wooden cribs 60 ft long by 36 to 60 ft wide, and varying in depth from 40 to 70 ft. These cribs were set in two U-shaped cofferdams.

On the Washington upstream leg the cribs were placed in flows up to 300,000 cu ft per sec in water 60 ft deep with estimated velocities up to 10 ft per sec. An enormous boulder, lying about 2,000 ft upstream of the cribs, was used as an anchor. Around this rock was placed the loop of a 2,400-ft piece of 3-in. lock coil cable, as shown in the photograph. This loop was clamped off by means of special plates so that an unbalanced pull on either of the two tail lines would not cause the rope to slip around the rock. The two leads were then carried downstream to bridge sockets, upon each of which were mounted a heavy loop and two sheaves. The loop of the socket was fitted over a pin which, in turn, ran through plates from which four 2-in. cables led to the frame of the main hoists.

BOULDER USED AS ANCHOR IN BACKGROUND
In Foreground Are Barges Supporting Main Hoists

The main hoists were supported by 40 by 108-ft barges. On these barges and fastened to the main hoists were auxiliary hoists for maneuvering and lowering the hoist barge. The rigging between the hoists and the cribs consisted of a $1^1/_2$-in. steel center wire rope from the drum of the main hoists to and through the lower pair of attachments on the crib, rigged in four parts.

The cribs were moved to a position in the quiet water behind the end crib of those previously placed. The pin holding the main barge and hoist to the 3-in. line was then pulled and the barge dropped down almost to the line of the cribs. After this, ropes were reeved and the barge was pulled upstream until the pin could be set in the loop of the bridge sockets.

The crib, drawing approximately 10 ft of water, was dragged upstream against the current, with a differential in head of about 4 ft between its upstream and downstream faces. When stresses reached approximately 100,000 lb per line, a second pair of crib attachments was rigged to the second main barge. The cribs were spotted from 3 to 5 ft upstream of their theoretical position, to allow for adjustment and line stretch.

The third set of holding lines were reeved as the crib approached the bottom. The crib was then held by twelve parts of $1^1/_2$-in. cable, each stressed up to 100,000 lb or better. During the time the crib was being filled, there was a tendency for it to settle on its base and to compress the timbers forming it. Both of these actions tended to stretch the holding lines, and it was a nice problem in judgment as to how much slacking off could be done without letting the crib move downstream.

An interesting relationship exists between the load per square foot of exposed upstream surface as measured by the stresses in the holding lines and that indicated by the difference in head. This relationship was not a constant one, since the stresses in the lines rise much more sharply than the head differential would indicate. It is believed that the operation just described is unique, particularly with respect to the depth and velocity of the water in which the large cribs were placed.

ARTHUR DONALDSON, Assoc. M. Am. Soc. C.E.
Office Engineer, Columbia Construction Company

Bonneville, Ore.
October 7, 1936

Factors Affecting Irrigation in Western Washington

TO THE EDITOR: As George E. Goodwin, M. Am. Soc. C.E., points out in his article on irrigation west of the Cascades, in the October number, the need for irrigation in western Washington is occasioned by two principal factors: Insufficient rainfall during the crop-growing season and low moisture-holding capacity of the average soil of the region.

Organized irrigation enterprises have so far been confined to the Sequim area in Clallam County, where four irrigation districts embrace 14,000 acres, of which 6,000 are irrigated, and the Yelm irrigation district in Thurston County, with a total area of 7,000 acres, of which 3,000 acres are at present irrigated. Both areas are supplied by gravity. The major parts of these irrigated regions were treeless prairie lands with rather coarse and excessively drained soils and subsoils, which are unproductive without irrigation. Under present conditions, the economic feasibility of providing irrigation water for unimproved, logged-off areas is very questionable. Irrigation for the extensive prairie lands between Tacoma and Centralia may become practicable in the not too distant future. Even though these soils are of lower average grade than those in timbered areas, the saving in clearing more than offsets the costs of irrigation and necessary upbuilding of fertility.

Elsewhere in western Washington irrigation is at present confined to small-scale individual enterprises, with water obtained from streams, springs, and wells. Most farmers pump their supply with electric power which is generally available. For some time to come, the extension of irrigation in this area will probably be confined largely to small individual enterprises. When the benefits of irrigation become generally recognized and when the demand for agricultural products justifies increased production, extension of irrigation will naturally follow.

Surface supplies from rivers, creeks, and numerous small lakes

are generally abundant, and storage will hardly be necessary. These sources are favorably distributed with reference to the lands likely to ultimately require water, thus permitting development in small units at reasonable cost. Diversions from streams and lakes for irrigation would almost invariably be located below any feasible power developments, and the two uses of water will not conflict.

Ground water is always obtainable in this region, but depths and quantities are generally variable and unpredictable. Exceptions are the glacial outwash plains between Tacoma and Centralia, where ground water is known to be abundant and the water table is within economical reach. Ultimately fair-sized developments may be reasonably anticipated in such major valleys as those of the Nooksack, Skagit, Stilaguamish, Snohomish, Green, Puyallup, Chehalis, and Cowlitz rivers, where soil, topography, water supply, existing settlement, and marketing conditions for agricultural products are favorable.

Total water requirements as well as monthly distribution of demand are extremely variable, due to variations in precipitation and in soils and subsoils. April and May, for instance, may be too wet for planting and seeding, or again almost devoid of precipitation. Similarly the last half of August and all of September may be a period of near maximum water demand or one of abundant, if not continuous, rainfall. Periods exceeding one hundred days without measurable rainfall are not unknown.

It is therefore evident that in western Washington where normal stream flow is, generally speaking, ample for all prospective irrigation use, the maximum rate of demand is a more important factor in determining feasibility of a given project than is the total seasonal water requirement. Thus in preparing for irrigation development in western Washington, it seems highly important to determine as far as possible in advance, and by actual field experiments, the maximum rates of water application required for various crops by the numerous and widely differing soil types likely to be brought under irrigation.

CHARLES J. BARTHOLET, M. Am. Soc. C.E.
State Supervisor of Hydraulics,
Department of Conservation and Development

Olympia, Wash.
September 28, 1936

Comments on Manual No. 11

DEAR SIR: A few of the definitions in the Society's Manual No. 11, "Letter Symbols and Glossary for Hydraulics," seem to be in need of revision. On page 4, we find the term "conjugate" applied to depths before and after the hydraulic jump. This term is not defined in the glossary, and unless it is carefully defined so that its meaning is restricted to this special sense, it had better be omitted. Otherwise, there is the possibility that it will be interpreted to apply to the depths of equal energy of flow, commonly referred to as alternate depths.

In the definition of the bore, on page 9, and of the hydraulic jump, on page 20, it is stated that the hydraulic jump "represents the limiting condition of the surface curve wherein it tends to become perpendicular to the stream bed." If this statement means that the surface of the hydraulic jump tends to become perpendicular to the stream bed, it is misleading, for the jump has a length, commonly four or five times its height. If the statement refers to the end of the backwater curve, where it tends to become vertical as it crosses the critical depth, it is incorrect. As the depth of flow approaches this point, the depths before and after the jump become nearly equal, and the jump finally degenerates into a standing wave which lacks the impact, turbulence, and energy loss that characterize the true hydraulic jump. I suggest the following definition for hydraulic jump—"the sudden and turbulent passage of water from low stage below critical depth to high stage above critical depth, during which the velocity passes from supercritical to subcritical. The jump is accompanied by impact and loss of energy. The relation of depths can be determined by use of the theorem of conservation of momentum."

CHESLEY J. POSEY, Jun. Am. Soc. C.E.
Assistant Professor of Mechanics and Hydraulics, State University of Iowa

Iowa City, Iowa
October 10, 1936

Obsolescence in Highway Design

TO THE EDITOR: I should like to comment on the article, "Highway Design Applied to the State System," by Mr. R. H. Baldock, in the October issue. In the western parts of both Oregon and Washington, heavy forests and dense growth of vegetation very materially limit the vision and operations of reconnaissance and locating parties. In Washington there are numerous instances of locations, made only a few years ago through such areas, that are definitely obsolete at the present time. When these routes were constructed, it was felt that the proper location had been secured. However, the timber has now been removed, and it is very evident in many instances that the proper location was not secured. By the correct use of aerial mosaics and aerial reconnaissance, such errors can be almost entirely eliminated. It should be pointed out, however, that aerial mapping is of value only if it is accurately done.

As pointed out by Mr. Baldock, we have found that sketches similar to those used by architects have proved very helpful. Such sketches were first used in our bridge department in making preliminary layouts for all types of major structures. Recently, however, they have been found helpful in securing right of way on sections where the resultant property damage would be high and in areas where it is difficult to explain to adjacent property holders the results of proposed changes in grade and alignment. These sketches have also proved valuable in condemnation cases and are absolutely necessary in landscaping or roadside improvement projects. Engineers are apt to forget that standard maps and profiles are not readily understandable to the layman and that it is only through the use of photographs, pictures, and sketches that he can be made to understand fully the improvements and changes that are contemplated.

Perhaps the most important feature covered in Mr. Baldock's paper is the matter of obsolescence. For many years highway engineers have given careful attention to the proper use of both concrete and bituminous materials for roadway surfaces. However, it is now apparent that too little thought has been given to the matter of location standards and design of roadway sections. Unfortunately, obsolescence is often most pronounced on highways carrying the heaviest traffic and connecting the most populous centers, for naturally it was such roads that were first improved.

It is often asked why this condition exists. This question can probably be best answered by referring to the increased motor-vehicle registration and the improvements made in automobiles during the past few years. In 1904 there were 8,000 motor vehicles registered in the United States; in 1936 there were 26,000,000. A few years ago speeds of 35 and 40 miles an hour approached the maximum for automobiles; the present-day motor car is capable of speeds of from 80 to 90 miles an hour. Fifteen or twenty years ago, roadbuilders could not reasonably anticipate such far-reaching changes.

In view of what has happened in the past, it may well be asked whether future developments will not render obsolete the present high standards of construction. A definite negative answer cannot be given; the future keeps its own counsel. Nevertheless, it may be said that the future will never make a 2-deg curve as awkward to negotiate as a 20-deg curve, and the future can never render obsolete good visibility, once it is attained.

The information contained in Mr. Baldock's paper should be considered as basic for the design of both primary and secondary highways. The standards of design as presented are essentially the same as those used by the Washington State Highway Department. I believe that they will prove adequate for future traffic requirements. Refinements, such as transition or spiralled curves, changes in superelevation, and soil stabilization, are all necessary. However, if we adhere closely to the standards now established throughout the western states and if we benefit by the surveys now being carried on under the direction of the U. S. Bureau of Public Roads, it can be definitely predicted that obsolescence will not deal with the work of today as it has dealt with the work of twenty years ago.

LACEY V. MURROW, Assoc. M. Am. Soc. C.E.
Director of Highways, Washington State Highway Department

Olympia, Wash.
October 6, 1936

SOCIETY AFFAIRS

Official and Semi-Official

Fall Meeting Covers Wide Range of Timely Subjects

A TECHNICAL PROGRAM so broad in its scope as to attract men in almost every branch of civil engineering brought an unusually large attendance to the Fall Meeting of the Society, which convened in Pittsburgh on October 13. River control, power economics, highway problems, surveying, and materials of construction were all treated in well-correlated symposiums presented over a two-day period. In all, the work of eight Technical Divisions was represented.

A Varied Program

The Cleveland and Central Ohio Sections shared honors with the Pittsburgh Section in making the program a success. The Central Ohio Section cooperated with the Highway Division in preparing two sessions on highway design and construction, and the Cleveland Section joined the Sanitary Engineering Division in two sessions on stream pollution. The Pittsburgh Section itself, in addition to performing its duties as host, worked with the Structural Division in presenting four sessions on the structural applications of steel and light-weight alloys; with the City Planning Division in two sessions on the traffic and financial problems involved in the planning of major highways; and with the Surveying and Mapping Division in a single session on the state system of plane coordinates.

On the opening day the general sessions were given over to papers on flood control, special attention being paid to the eastern floods of 1936, the economic aspects of flood control, and the problems of a national flood-protection policy. These subjects were further pursued in two technical sessions on the following day, under the auspices of the Waterways Division. At the afternoon meeting the questions of flood control centering around Pittsburgh and the Ohio Valley were developed in detail. Partly because of the appeal of this topic and partly because of the excellent presentation of these local and community problems, this session drew the banner attendance of the meeting. Almost 300 members were present and gave careful and appreciative attention to every point.

In addition to the symposiums already mentioned, two on the economic aspects of energy generation were sponsored jointly by the Power Division and the Engineering-Economics and Finance Division. The several papers presented bore evidence of careful coordination and long practical experience on the part of their writers. The same might be said equally well of the symposium on the State System of Plane Coordinates and the one covering two sessions on Planning of Major Highways. The reception in each case was enthusiastic, so much so that the authors felt well repaid for their efforts.

Nearby Sections Lend a Hand

The participation of two neighboring Local Sections in a number of the technical sessions was an innovation that deserves special mention. While it is true that the Cleveland and Central Ohio Sections were centered only a few hundred miles away, in Ohio, yet some misgivings were naturally felt as to whether the arrangement would prove a success. However, the experience in both instances was all that could be desired. The program was well conceived and carefully presented; interest was sustained from start to finish; and the attendance was excellent. The highway program boasted of an audience larger than any within the memory of the Division officers. Well-directed

© *Fairchild Aerial Surveys from Wide World*

PITTSBURGH'S GOLDEN TRIANGLE—THE CENTER OF MUCH OF THE NATION'S TRAFFIC IN METALS

cooperation certainly showed to good effect here as elsewhere.

Unquestionably the most ambitious program was that undertaken by the Structural Division in its symposium on Steel and Light-Weight Alloys. This covered two entire days, or four sessions consecutively. In spite of this length, interest and attention did not flag. The dozen speakers held their audiences well in the face of three and sometimes four counter-attractions. Doubtless the total attendance at this symposium outdistanced the others. The subjects particularly appealed to Pittsburgh engineers, it is true, but probably the greatest favorable factor was the intelligent assembly of component topics and the careful selection of specialized experts as authors. As one of the officers remarked when asked if this symposium was all right, "It is more than 'all right!'" This was the general reaction.

Engineers as Patrons of Art

The enthusiasm with which members and their guests participated in the social events demonstrated again that much of the value of the quarterly meetings lies in the spirit of good fellowship that they engender. Luncheons for special groups were scheduled for each day of the meeting, and the evenings were given over to a variety of entertaining functions. On Tuesday evening there was a smoker for the men, while the ladies enjoyed

Louis C. Hill for Society President in 1937

Louis Clarence Hill, of Los Angeles, Calif., was selected by the Nominating Committee at its meeting in Pittsburgh on October 11, 1936, as the official nominee for President of the Society for 1937. His name, together with those of the official nominees for other Society offices, will appear on the final ballot, to be voted on in January by all Corporate Members in good standing.

In his 50 years of professional practice, Mr. Hill has achieved an international reputation in the field of dam design and irrigation development. He has had an important part in many of the large reclamation projects of the West, of Canada, and of Mexico, and of late years has served as consulting engineer to both the Department of the Interior and the War Department on large dams in all parts of the country. His nomination to the highest post in the Society is at once a recognition of past achievement and an invitation to further service to the profession.

A brief biography of Mr. Hill will be published in a later issue.

a separate program that included motion pictures and a floor show. The following night, members, ladies, and guests were privileged to attend a preview of Carnegie Institute's famous annual International Art Exhibit. This event was followed by a party at the William Penn Hotel, with dancing, supper, and a floor show. On Thursday the social events were brought to a close with a dinner dance, also held at the William Penn.

During the technical sessions, the ladies were kept busy with a round of delightful motor drives, luncheons, and parties. A group which took a fascinating trip through the H. J. Heinz food products plant—including incidentally a delectable lunch—is pictured in an accompanying photograph.

THE LADIES HAD THEIR OWN INSPECTION TRIP
Feminine Visitors at the Fall Meeting, Photographed on the Steps of the H. J. Heinz Company Plant

On Friday the Fall Meeting was concluded with inspection trips to the Homestead and Schoen plants of the Carnegie-Illinois Steel Company, the New Kensington plant of the Aluminum Company of America, and the hydraulic laboratory of the Carnegie Institute of Technology. At the Homestead plant the visitors watched the rolling of plates, sheet piling, and structural shapes, and the operation of the open-hearth furnaces. At the Schoen plant, armored bridge floors and rolled steel wheels were being produced. The hydraulic laboratory at Carnegie Institute gave an interesting demonstration of models of the Tygart River Dam in the upper Monongahela basin, the Emsworth Dam on the Ohio River just below Pittsburgh, and the Bluestone Dam in West Virginia. At New Kensington the guests saw experiments of many kinds in progress on model structures of aluminum alloys and fatigue and creep tests on specimens of the same material, and inspected the extensive metallurgical laboratories. Excellent lunches were provided for each of the two separate groups of visitors, one by the Steel and the other by the Aluminum Company.

SECTIONS AND STUDENTS TAKE PROMINENT PARTS

In connection with the Fall Meeting two conferences of importance to the Society took place. The Local Sections conference on October 12 brought together the representatives of 21 Local Sections for a round-table discussion of Section activities. Plans were also made for the 1937 Fall Meeting. On Thursday, October 16, the Student Chapter conference was attended by 105 representatives, faculty advisers, and contact members from 15 Student Chapters. The students, 90 in number, demonstrated their ability to conduct a lively meeting. The older men in turn were able to sit back and marvel as one after another of these undergraduates, 40 in all, stood up and gave their contributions to the discussion of four scheduled topics of interest to Student Chapters. It was well observed that at least the coming generation of engineers will not be inarticulate.

It would be difficult to give adequate individual acknowledgment here to the many persons who had some part in making the Fall Meeting a success. Some 100 members and more than 20 ladies served on the various committees on arrangements, and 76 persons contributed papers, formal discussions, or addresses; further behind the scenes were the Technical Division committees that laid the ground work for much of the program. The entire group deserves congratulations for an earnest, cooperative, and all-inclusive effort. How well their efforts were rewarded is evident from the attendance, which totaled almost 800. The interest and enjoyment were proportionately great.

Meeting of Board of Direction October 11, 12, and 13, 1936—Secretary's Abstract

ON October 11, 12, and 13 the Board of Direction met at the William Penn Hotel in Pittsburgh, Pa., with President Daniel W. Mead in the chair, and present George T. Seabury, Secretary; Past-Presidents Eddy and Tuttle; Vice-Presidents Dennis, Lupfer, Riggs, and Sawyer; Directors Ammann, Arneson, Barbour, Burdick, Crawford, Etcheverry, Ferebee, Finch, Hidinger, Hill, Leisen, McDonald, Morse, Myers, Poole, Proctor, Stabler, Trout, Wilkerson; and Treasurer Hovey. It was announced that every member of the Board was in attendance.

Approval of Minutes

The Board approved the minutes of the meeting of July 13 and 14, 1936; also those of the Executive Committee meeting on October 11, 1936.

Executive Committee Actions

Various actions and recommendations of the Executive Committee were reported to the Board. (These are incorporated in the Board minutes and are not listed separately as in reports of previous Executive Committee meetings.)

Nominating Committee Reports

In accordance with the Constitution, the Nominating Committee met at the time of this Board meeting. Its unanimous selection of Louis C. Hill, M. Am. Soc. C.E., of Los Angeles, Calif., as the "official nominee" for president for 1937, was reported to the Secretary and transmitted to the Board.

Soil Mechanics and Foundations Division

The Board approved the constitution and definition of scope of the Soil Mechanics and Foundations Division which it had previously authorized at its July 1936 meeting. The Committee on Earths and Foundations was transferred from the jurisdiction of the Research Committee to that of the Division's executive committee.

Members of the Executive Committee were appointed to include the following: W. P. Creager of Buffalo, N.Y. (1 year term); C. S. Proctor of New York, N.Y. (2 years); J. F. Coleman of New Orleans, La. (3 years); F. A. Marston of Boston, Mass. (4 years); and R. V. Labarre of Los Angeles, Calif. (5 years). Mr. Proctor was designated as chairman, and T. T. Knappen as secretary.

Division Executive Committee Appointments

On recommendation of the executive committees of the various Technical Divisions, the Board appointed new members of these executive committees for five-year terms to take the place of those members whose terms expire in January 1937. These new committee officers are listed in complete form on another page.

Society Prizes

The Board adopted the report of the Committee on Prizes for papers appearing in Volume 100 of TRANSACTIONS, designating the recipients as given elsewhere in this issue in full.

Local Section Constitutions

Approval was given to changes in the constitution or by-laws as requested by the San Francisco, Louisiana, Panama, and Colorado Sections.

Custis Lee Student Chapter Withdraws

Letter of resignation was received from the Custis Lee Engineering Society Student Chapter at Washington and Lee University, on account of the decision of the University to abandon the department of engineering. The Board accepted with regret.

Life Members

By regular procedure the Society's By-Laws were changed to provide for the designation, "Life Members," as indicated more fully in a separate item.

New Honorary Members

The Board canvassed ballots which resulted in the election of five new Honorary Members, the maximum number permissible in any one year. The following Members were thus chosen: Alex Dow, George H. Duggan, Robert Hoffmann, J. B. Lippincott, and J. A. L.

Waddell. Further information on these Honorary Members is given in a separate item.

Semicentennial of Engineering Institute of Canada

Invitation was received from the Engineering Institute of Canada for the Society to be represented at the meeting celebrating its fiftieth anniversary, in Montreal, beginning June 15, 1937, as a guest of the Institute. In cordially accepting, the Board appointed the incoming president to represent the Society.

Allocation of Members to Sections

Directors individually reported on inquiries they each had made in conference with officers of the various Local Sections in their several districts regarding the advisability of adopting a program involving the allocation of all members to some Local Section already existing or newly to be formed. Results of similar discussions before Local Section conferences of the Southeastern Region in April 1936 at Hot Springs, of the Western Region in July 1936 at Portland, and of the Northeastern and Middle Western Regions in October 1936 at Pittsburgh were discussed. The Local Section Committee and the Secretary were requested to study all the data thus accumulated and report to the Board at its January meeting.

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Reports Received

Reports were presented from the Society's Committee on National Water Policy, from United Engineering Trustees, Inc., from Engineering Foundation, from American Engineering Council, from the Construction League of the United States, and from Engineers' Council for Professional Development.

Furthering Interests of Members

Upon recommendation of the Executive Committee, the Board adopted "as a guiding principle, the policy of furthering the interests of all the members of the American Society of Civil Engineers as far as may be consistent with a high plane of professional standards and ethics."

Budget Matters

Upon recommendation of the Executive Committee, certain readjustments were made in the budget, approving a contribution to the work of the Engineers' Council for Professional Development, and an allotment to United Engineering Trustees, Inc., for its depreciation and renewal fund.

Professional Conduct

The Committee on Professional Conduct reported on several matters. Certain of the cases of alleged unprofessional conduct had to do with the furnishing of engineering reports, information, or data, without charge or on a contingent basis.

The committee also reported on requests received for restoration to membership of certain persons previously expelled. The Board's action was to continue this matter in the hands of the committee for report to the next meeting of the Board.

The Board ruled upon the circumstances and manner under which, in answer to a hypothetical question submitted, it is not unprofessional and inconsistent with honorable and dignified bearing for an engineer to review the work of another engineer either with or without his consent. See page 768 of this issue.

Districts and Zones

The Committee on Districts and Zones recommended that there be no change in the boundaries of the Districts and Zones for the election procedure of 1937.

Flood Control

Formation of a "Committee on Flood Control" was authorized, for the purpose of making a general appraisal of flood control methods with particular reference to their physical and economic limitations. Funds for this committee work were appropriated.

Weather Bureau

A resolution was adopted endorsing improvements in the service of the Weather Bureau and the provision of adequate increase in appropriation therefor. Details are given in a separate item.

Appointments

Appointments were approved as follows: President Daniel W. Mead on the John Fritz Medal Board of Award to take the place of Herbert S. Crocker, whose term expires in October 1936; and the following Society representatives to American Engineering Council: Alonzo J. Hammond, Daniel W. Mead, George T. Seabury, Arthur S. Tuttle, and the incoming president.

Routine Matters

As is usual, a number of administrative and routine matters were presented and acted upon.

Adjournment

The Board adjourned to meet at New York, N.Y., on January 18, 1937.

Memoirs of Deceased Members

Among the latest memoirs of deceased members available are two Honorary Members, ten Members, one Associate Member, and one Junior. The accumulated record of their professional achievement has been intimately connected with the Society over a period of 43 years. The preprints now available will be published in Vol. 102 of Transactions to be issued next year:

Ernest William Branch	1883–1936
Leonard John Butler	1912–1936
George J. Calder	1884–1936
John Hirst Caton, 3d	1883–1936
Joseph Firth	1878–1936
Milo Smith Ketchum	1872–1934
George Casper Doering Lenth	1882–1936
Charles Albert McKenney	1870–1935
Elwood Mead	1858–1936
James Edwin Parker	1884–1934
Reenen Jacob Van Reenen	1884–1935
Earl Stimson	1873–1936
Charles Louis Strobel	1852–1936
Aaron Stanton Zinn	1862–1936

Society Officers Nominated for 1937

On October 15 the second ballot was canvassed to determine nominees other than president for Society offices to be filled in January 1937. The report of the tellers on this ballot is printed in full elsewhere in this issue. In accordance with Article VII, Section 4 of the Constitution, the candidate for the office of president was chosen by the Nominating Committee on October 11. The complete list of nominees is as follows:

For President:
Louis C. Hill, of Los Angeles, Calif.

For Vice-Presidents:
Zone II, L. F. Bellinger, of Atlanta, Ga.
Zone III, R. C. Gowdy, of Denver, Colo.

For Directors:
District 1, William J. Shea and Enoch R. Needles, of New York (two to be elected)

District 2, Arthur W. Dean, of Boston, Mass.
District 6, R. P. Davis, of Morgantown, W.Va.
District 10, T. Keith Legaré, of Columbia, S.C.
District 13, Thomas E. Stanton, Jr., of Sacramento, Calif.

These nominees will be voted on by the use of final ballots sent to every Corporate Member 40 days before the Annual Meeting in January. The ballots will be canvassed one week before the Annual Meeting, and the elected officers will be inducted into office at the Meeting.

Endorsement of Weather Bureau

CONTACTS of the Society's Committee on Meteorological Data with the program and work of the U. S. Weather Bureau have convinced the committee that the Bureau should receive public support in its efforts to enlarge and improve its service. With this in mind, the Board of Direction at its Pittsburgh meeting voiced its approval of this government activity by adopting the following resolution:

WHEREAS, more accurate and complete meteorological data are essential to many branches of human endeavor including navigation, agriculture, aviation, and engineering; and

WHEREAS, the Special Committee on Meteorological Data of the American Society of Civil Engineers, the Water Resources Committee of the National Resources Committee, and the Advisory Committee to the Secretary of Agriculture on the Weather Bureau have all urged the expansion and improvement of the service furnished by that Bureau, which will call for an increase in appropriations for the Bureau, now deemed inadequate even for the present service;

Therefore, be it resolved, by the Board of Direction of the American Society of Civil Engineers that it endorses improvements in the service of the Weather Bureau, and the provision of an adequate increase in appropriation therfor, especially along the following lines:

a) Stimulation of the service by adding qualified new men, by additional training of selected men now in the present organization, by further personal contact between field and office officials, and by regular inspections of both first-order and voluntary stations.

b) Research.

c) Extension of upper-air observations to obtain, if possible, more exact and longer range forecasting.

d) Increased number of observation stations, especially in the high mountain areas, and reports from more ships at sea.

e) Snow surveys and evaporation observations from water, snow, and soils.

f) The complete adoption and use of the International Figure Code.

Organization of New Technical Division Completed

AT ITS meeting in Pittsburgh on October 11, the Board of Direction gave final approval to the establishment of a new Technical Division of the Society, to be known as the Soil Mechanics and Foundations Division. The preliminary work of organization has been under way for several months, and already more than 150 members have been enrolled. Some 60 of them have already contributed suggestions relative to organization and scope of activities.

A detailed statement of the plans of the new Division will appear in a later issue. It may be stated now, however, that six committees have already been authorized. Two will take over the work of the existing Research Committee on Earths and Foundations. Another will arrange a program for the first technical session of the Division, to be held in October 1937. A fourth committee, on pile-driving formulas and tests, will work jointly with the similar committee of the Waterways Division. The remaining two are charged respectively with compiling a bibliography on soil mechanics and preparing a glossary of terms on the same subject, as well as reporting on the classification of soils. The Division's executive committee is proceeding with a careful study of a unified program before setting up additional committees and in the meantime will welcome further suggestions from the membership.

With the thought that many who have not yet had the opportunity to do so will wish to affiliate themselves with the new unit, the following brief review of the general purposes and work of the Technical Divisions is presented.

Technical Divisions constitute the Society's medium for the advancement of its technical work. They may be organized for the consideration of any engineering, scientific, or professional subject. Membership in one or more Divisions is the prerogative of every member of the Society, and may be obtained on written request to Society Headquarters. Such membership identifies one as being interested in the particular specialty of the Division to the extent of wishing to be kept advised of matters pertinent to that subject, and of being considered as available to assist by participation in programs or on committee work.

It is the function of a Technical Division to assume leadership in matters embraced within its specialized field. It originates and pursues inquiries along new lines; it constantly surveys the field and records advances and improvements as they are made; it elicits authoritative papers.

Much of the material published by the Society is produced under the sponsorship of the Technical Divisions. Progress reports of the various Division committees appear from time to time in PROCEEDINGS, where they are discussed by the membership at large. Some of these later form the basis for final reports; others may be shaped into Manuals, designed to contain information useful to the average engineer in his everyday work. The Divisions also formulate a large part of the technical programs of the quarterly meetings of the Society, and obtain speakers for them. Papers thus presented appear later in abstracted form in CIVIL ENGINEERING, or, if the subject and presentation seem to warrant extensive discussion, they may be published in full in PROCEEDINGS.

With the newest addition, there are now 11 Technical Divisions, each carrying on its work through an executive committee and such technical committees as are required. Of the latter there are at present a total of 50; the membership and general purpose of each is given in the current Year Book.

Ethics of Reviewing Another Engineer's Work Without His Consent

AMONG OTHER THINGS, the Society's Code of Ethics provides (Paragraph 5) that it shall be considered unprofessional and inconsistent with honorable and dignified bearing for any member of the Society "to review the work of another engineer for the same client except with the knowledge and consent of such engineer or unless the connection of such engineer with the work has been terminated." A hypothetical question covering this provision was submitted to the Society's Committee on Professional Conduct and by the committee referred to the Board at its Pittsburgh meeting with a suggested answer. The committee's interpretation, as noted in the following, was approved by the Board.

Hypothetical Question:

"A client wishes to have the work of Engineer A reviewed and askes Engineer B to make such review. Engineer B advises Engineer A of the proposed engagement. Engineer A refuses to give his consent. Under these conditions, is Engineer B free to accept the engagement and make the review requested?"

Answer as Approved by Board of Direction:

"It shall not be considered unprofessional and inconsistent with honorable and dignified bearing for an engineer to review the work of another engineer either with or without the consent of that engineer provided he is courteously informed of the proposed review and, further, that the reviewing engineer provides the original engineer with as full opportunity as possible to explain his original work."

Pittsburgh Meeting Publicity

Publicity efforts for the Fall Meeting of the Society penetrated to the local headlines in Pittsburgh newspapers and received considerable attention on the wires of national news agencies, despite the fact that Pittsburgh is one of the principal battle grounds of the national political campaigns and that the city itself is in the throes of a most unusual mayoralty situation. While it is too early to make more than a preliminary estimate of space obtained, clippings from 36 cities, averaging more than one-half column each, are on hand.

Interest in the flood control papers ranged high in cities throughout the flood areas, and it is anticipated that many additional

Wider Publicity Is Being Accorded Society Activities by the Daily Press

Samples of Newspaper Accounts Written Around Official Releases of the Society's Publicity Department on the Annual Convention in Portland, Ore. Clippings Totaling Over 1,260 Column Inches About the Convention Are on File at Society Headquarters

clippings on that subject will be received before this issue of Civil Engineering leaves the press. Further interest was attracted by papers dealing with the participation of the U. S. Weather Bureau in matters of flood control and resulted in the publication of constructive news stories. The headline on one news story of the flood symposium stated, "BIG EXPANSION FOR WEATHER BUREAU URGED—Vital In Any Flood Control."

An editorial in connection with the meeting which appeared in the Pittsburgh *Post-Gazette* on October 15, outlined the tremendous flood tolls in loss of life, homes, buildings, and other property, and added: "The engineers know how to stop this sacrifice of resources, through impounding waters in seasons of excessive precipitation and release of waters in dry seasons. . . . When the legislators catch up with the engineers, the problem will be advanced on its way toward solution."

The two examples quoted are typical of the constructive cooperation obtained by the Society's publicity department from newspapers despite the fact that their available space and man power were sadly depleted by an avalanche of important news from other sources.

Appointments on Division Executive Committees

In accordance with the By-Laws, ten Corporate Members of the Society were appointed by the Board at its meeting on October 11, 1936, to be members of the Executive Committees having charge of the affairs of the various Divisions. These appointments were made following nominations by the Nominating Committee of each Division, as required by Article VIII, Section 3 of the By-Laws.

Appointments of the following members were made for a term of five years:

Division	New Committee Member
City Planning	W. J. Fox
Construction	S. D. Bechtel
Engineering-Economics and Finance	Fred Lavis
Highway	W. N. Carey
Irrigation	R. J. Tipton
Power	O. G. Thurlow
Sanitary Engineering	A. D. Weston
Structural	Shortridge Hardesty
Surveying and Mapping	Philip Kissam
Waterways	L. C. Sabin

By-Laws Amended to Recognize Life Members

At a meeting of the Board of Direction on October 11, 1936, an amendment to the By-Laws was adopted changing Section 5, Article II, and adding new Sections 5 and 6.

The section struck out previously read:

"5. Every person admitted to the Society shall be considered as belonging thereto and liable for the payment of all dues until he shall have resigned, been expelled, or have been relieved therefrom by the Board of Direction."

The new form of Section 5 is as follows:

"5. Every person admitted to the Society shall be liable for the payment of all dues until his membership is terminated, unless he has been relieved from the payment thereof by action of the Board of Direction, or as provided in Article IV, Section 7 of the Constitution."

A new Section 6 was added, as follows:

"6. Those Corporate Members and Affiliates who become exempt from the payment of dues under the provisions of Article IV, Section 7 of the Constitution, shall thereafter be known as Life Members, but the use of this term shall not be construed to establish a separate grade of membership."

Engineers' Council Reelects Scott

Charles F. Scott, professor emeritus of electrical engineering at Yale University, was reelected chairman of the Engineers' Council for Professional Development at the fourth annual meeting of the Council held in New York on October 6. At the morning session, in addition to the election of officers and chairmen of committees, reports of the Council's committees were presented. Interest centered around the report of the Committee on Engineering Schools, and at afternoon and evening sessions formal action on the accrediting of engineering curricula of educational institutions in New England and Middle Atlantic states was taken. Pending formal notification of the institutions involved in the accrediting procedure, the lists have not been made public.

H. H. Henline, national secretary, American Institute of Electrical Engineers, was elected secretary of the Council. By action of the Council the by-laws were amended to provide for the offices of vice-chairman and assistant secretary, and R. I. Rees, assistant vice-president, American Telephone and Telegraph Company, was elected vice-chairman, and C. E. Davies, secretary of the American Society of Mechanical Engineers, was elected assistant secretary. Chairmen of the Council's committees were elected as follows: Student Selection and Guidance, Robert L. Sackett, dean of engineering, Pennsylvania State College; Engineering Schools, Karl

T. Compton, president, Massachusetts Institute of Technology; Professional Training, R. I. Rees; Professional Recognition, Conrad N. Lauer, president, Philadelphia Gas Works; Ways and Means, R. I. Rees; and Information, H. C. Parmelee, editorial director, *Engineering and Mining Journal*.

Executive Committee members elected were: J. P. H. Perry (Am. Soc. C.E.), F. M. Becket (A.I.M.E.), C. F. Hirshfeld (A.S.M.E.), L. W. W. Morrow (A.I.E.E.), H. C. Parmelee (A.I. Ch.E.), R. I. Rees (S.P.E.E.), D. B. Steinman (N.C.S.B.E.E.).

In addition to the report of the Committee on Engineering Schools, reports of the Committees on Student Selection and Guidance and on Professional Training were approved. The report of the Committee on Professional Recognition was received and held over for discussion at a meeting to be called at some later date.

The report of the Committee on Student Selection and Guidance, of which R. L. Sackett, dean of engineering, Pennsylvania State College, is chairman, was devoted to the committee's studies of cooperative tests in English and mathematics with which it has been experimenting in an effort to find a reliable means of predicting a young student's ability to complete a course in engineering training. Results of attempts on the part of the committee to encourage local groups throughout the country in intelligent selection and guidance of students were reported.

In the report of the Committee on Professional Training, R. I. Rees told of the year's work with junior engineers recently graduated from college. Successful inauguration of organized classes of study for junior engineers of the Providence Engineering Society was announced. It was also reported that the committee had completed its "Selected Bibliography of Engineering Subjects" for young engineers who wish to continue study in allied fields of engineering.

The Engineers' Council for Professional Development is a conference of engineering bodies organized to enhance the professional status of the engineer through the cooperative support of the national organizations directly representing the professional, technical, educational, and legislative phases of the engineer's life. The participating bodies are the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the American Institute of Chemical Engineers, the Society for the Promotion of Engineering Education, and the National Council of State Boards of Engineering Examiners.

Report of the Tellers on Second Ballot for Official Nominees

To the Secretary *October 15, 1936*
American Society of Civil Engineers:

The tellers appointed to canvass the Second Ballot for Official Nominees report as follows:

Total number of ballots received		3,498
Excluded ballots:		
From members in arrears of dues	157	
Not signed	27	
With illegible signature	2	
From members who have died since voting	2	
From non-members	1	
Total ballots withheld from canvas		189
Ballots canvassed		3,309
For Vice-President, Zone II		
J. Houstoun Johnston	327	
L. F. Bellinger	409	
A. C. Polk	398	
Void	3	
Blank	11	
Total	1,148	
For Vice-President, Zone III		
R. C. Gowdy	449	
D. J. Brumley	285	
Chas. H. Paul	379	
Void	1	
Blank	2	
Total	1,116	

For Directors, District 1 (two to be elected)	
William J. Shea	473
Enoch R. Needles	423
R. E. Bakenhus	243
Void votes	0
Blank votes	39
Total votes registered	1,178
Total ballots received in District 1 (one-half of above figure)	589
For Director, District 2	
Arthur W. Dean	210
Void	1
Blank	0
Total	211
For Director, District 6	
R. P. Davis	170
Void	0
Blank	1
Total	171
For Director, District 10	
N. W. Dougherty	135
T. Keith Legaré	178
F. J. Lewis	97
Void	2
Blank	18
Total	430
For Director, District 13	
Thomas E. Stanton, Jr.	245
Void	0
Blank	0
Total	245

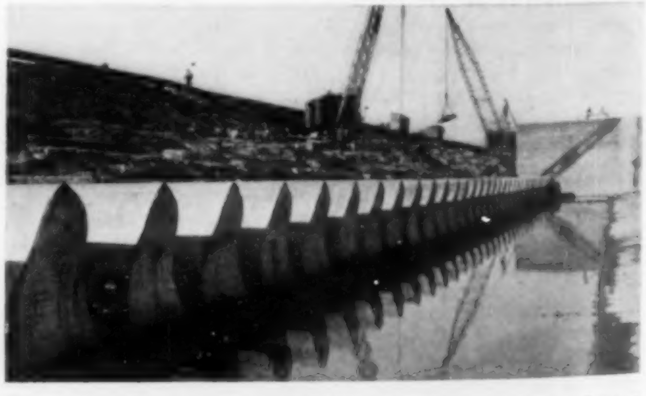
Respectfully submitted,

V. T. BOUGHTON, *Chairman*

A. H. Baker	Benjamin A. Hodgdon
Robert Stephenson	T. Grahlman
B. F. Biemann	Philip M. Parker
Charles D. Thomas	*Tellers*

Lantern Lectures in Demand

ON OCTOBER 10, when copy for this issue of CIVIL ENGINEERING was being made ready for the printer, there were on file nineteen advance reservations for the showing of the lantern lectures maintained for the use of Student Chapters. On that date, four showings had already been held, in or near the city of New York, and others were to take place shortly. These lectures, first released in the fall of 1929, and added to from time to time, continue to be popular with each new class of students.



ONE OF THE SLIDES FROM THE LECTURE ON WHEELER DAM SHOWS THE DENTATED SILL AT THE TOE OF THE APRON FOR DISSIPATING THE ENERGY IN THE FALLING WATER

DRILL HOLES AT NORRIS DAM WERE LARGE ENOUGH TO PERMIT ENGINEERS TO DESCEND IN THEM AND EXAMINE THE BEDROCK AT FIRST HAND—THIS SLIDE SHOWS THE CORES

The three new titles mentioned in the September number are now available. Two of these are descriptive of the work being done by the Tennessee Valley Authority. One shows the Norris Dam, and one the Wheeler Dam. Taken with the earlier release on the Wilson Dam, an outline is given of the development of the Tennessee Valley from the year 1918 to the present time. Another new lecture treats briefly of the substructure of the San Francisco–Oakland Bay Bridge, and the new type of caisson used on that work. Including the older lectures, and the revised edition of the lecture on Mississippi River Flood Control, the list now available comprises the following titles:

Aerial Photographic Mapping	Holland Tunnel
Carquinez Strait Bridge	Miami Flood Control
Cascade Tunnel	Mississippi River Flood Control
Catskill Water Supply	Norris Dam (Tennessee Valley)
Conowingo Hydro-Electric Development	Recent Power Development at Niagara Falls
Coolidge Dam	San Francisco–Oakland Bay Bridge —Substructure
Florianopolis Bridge	Westchester County Park System
George Washington Bridge	Wheeler Dam (Tennessee Valley)
Hetch Hetchy Water Supply and Power Plant	Wilson Dam at Muscle Shoals

Local Sections and other organizations have already found the lectures of great assistance in preparing a program. To the extent that such use of the lectures will not interfere with the activities of the Student Chapters, reservations from Sections will also be given consideration.

Convention to Be Held in Phoenix, November 12–14

A THREE-DAY convention to be held at Phoenix, Ariz., by members of District 11 of the Society, will feature irrigation and other engineering activities in the Salt River Valley of Arizona.

On Thursday, November 12, 1936, the Arizona Section will hold a meeting and a smoker. The convention proper will be opened at the Westward Ho Hotel, 9:30 a.m. on Friday with addresses of welcome by Governor B. B. Moeur of Arizona and Mayor John H. Udall of Phoenix. The response will be by Raymond A. Hill, Director from District 11. Daniel W. Mead, President of the Society, will also make an address.

The first technical paper, dealing with prehistoric irrigation in the Salt River valley, will be presented by Byron Cummings. W. W. Lane, M. Am. Soc. C.E., will then discuss irrigation development in Arizona. At a joint luncheon meeting with the Phoenix Chapter of the American Association of Engineers, Vernon Clark will describe early irrigation in the Salt River valley.

A paper on the construction of the Salt River project, by Louis C. Hill, nominee for president of the Society for 1937, will open the Friday afternoon session. Addresses on highways and on sanitary engineering in the valley, by T. S. O'Connell, M. Am. Soc. C.E., and Dario Travini, respectively, will be followed by a description of the water-supply studies preceding construction of the Roosevelt Dam, as summarized by Howard S. Reed, Assoc. M. Am. Soc. C.E. A banquet and ball will be held that evening.

Saturday will be occupied principally by an inspection trip to Horse Mesa Dam. The convention will be brought to a close at 5:00 p.m. with a desert picnic at Canyon Lake. For the ladies, a special entertainment will take place on Friday afternoon. Special trips to points of scenic or engineering interest may be arranged by members and guests. A large attendance is anticipated in view of the well-rounded program. All Society members are cordially invited to be present.

Papers Filed in Library

THREE PAPERS by members of the Society have recently been deposited in the Engineering Societies Library, 29 West 39th Street, New York, where they are available for reference. Prices for photostatic reproductions will be quoted by the library on request.

STAGNANT WATER IN CITY PONDS

FLEBUS, C. G., Assoc. M. Am. Soc. C.E.: "Stagnant Water in City Ponds" (3,500 words, plus 17 pp. tables, 14 pp. photographs of algae specimens, 5 pp. charts). This is a study of the biochemical oxygen demand of various living and dead algae, based on original field observations and laboratory work covering all the waters of the New York metropolitan area. The laboratory methods are described and a typical problem, determining the potential effect of algae on the oxygen content of a proposed lagoon, is worked out in detail. An album containing 18 specimens of sea algae accompanies the report.

STRUCTURAL ENGINEERING PROBLEMS

MOLITOR, DAVID A., M. Am. Soc. C.E., "Structural Engineering Problems" (about 90,000 words, including 60 tables and 61 drawings). The subjects dealt with are statically indeterminate beams, columns, and rigid frames, especially those met with in modern buildings of steel and reinforced concrete. Special attention is given to wind bracing, retaining-wall and sheet-piling design, and wave pressure on breakwaters. (The section on wave pressure appeared in the May 1934 PROCEEDINGS.) The principal methods of stress analysis are discussed, and the author selects a method based on Mohr's work equation as being the most satisfactory for general use because it is almost universally applicable, and because it does not involve the use of integration. Many examples are worked out in detail.

Engineering Curricula Accredited by Engineers' Council

FORMAL ACTION in accrediting engineering curricula in educational institutions in New England and Middle Atlantic states has been taken by the Engineers' Council for Professional Development.

The engineering curricula accredited are only those offered in educational institutions in the New England and Middle Atlantic states, as the Committee on Engineering Schools, which acts for the Council in making the investigations and reports on which the accrediting is based, has so far confined its work to these two areas. Hence the lists of accredited curricula should be considered in the nature of a progress report which will be supplemented when the Council has had an opportunity to extend its investigations to institutions in other parts of the country.

Curricula in schools in the United States, not included in the New England and Middle Atlantic areas, will be investigated during the coming year by the Committee on Engineering Schools, and a complete list of accredited curricula will be issued when approved by the Council. Only curricula in institutions making application to the Council were considered. Some institutions and some curricula in the New England and Middle Atlantic states may be added to the list as soon as certain criteria essential for judging them have been determined by the Council.

In drawing up its list of accredited engineering curricula, the entire Council considered every curriculum separately and based its decision on the reports made by a number of groups of engineers and educators who visited the institutions under the direction of the Council's Committee on Engineering Schools, of which Karl T. Compton, president, Massachusetts Institute of Technology, is chairman. Inspection visits were made by one of these groups to

90 per cent of the educational institutions in the areas mentioned offering engineering curricula leading to degrees, and were made only at the request of the institution formally applying for accrediting by the Council.

The basis for accrediting by the Engineers' Council was as follows:

Only undergraduate curricula leading to degrees were considered at this time.

Curricula, not institutions, were to be accredited and both qualitative and quantitative criteria were set up as a basis for final action.

Qualitative criteria were evaluated through the inspection committee and included the following:

1. Qualifications, experience, intellectual interests, attainments and professional productivity of members of the faculty
2. Standards and quality of instruction
   a) In the engineering departments
   b) In the scientific and other cooperating departments in which engineering students receive instruction
3. Scholastic work of students
4. Records of graduates both in graduate study and in practice
5. Attitude and policy of administration towards its engineering division and toward teaching, research, and scholarly production

Quantitative criteria were evaluated through the following data secured from catalogs and other publications and from questionnaires:

1. Auspices, control, and organization of the institution and of the engineering division
2. Curricula offered and degrees conferred
3. Age of the institution and of the individual curriculum
4. Basis of and requirements for admission of students
5. Number of students enrolled
   a) In the engineering college or division as a whole
   b) In the individual curriculum
6. Graduation requirements
7. Teaching staff and teaching loads
8. Physical facilities. The educational plant devoted to engineering education
9. Finances: investments, expenditures, sources of income

The list of accredited civil engineering curricula follows:

Brown University
Carnegie Institute of Technology (a)
Clarkson College of Technology
College of the City of New York (a)
Columbia University (b)
Cooper Union Institute of Technology (c)
Cornell University
Dartmouth College
University of Delaware
Drexel Institute (d)
Johns Hopkins University
Lafayette College
University of Maine
Massachusetts Institute of Technology
University of New Hampshire
New York University (c)
Newark College of Engineering
Norwich University
Pennsylvania State College
University of Pittsburgh
Polytechnic Institute of Brooklyn (a)
Princeton University
Rensselaer Polytechnic Institute
Rhode Island State College
Rutgers University
Swarthmore College
Syracuse University
Tufts College Engineering School
Union College
University of Vermont
Worcester Polytechnic Institute
Yale University

(a) Accrediting applies to both the day and evening curricula.

(b) Accrediting applies to the four-year and five-year curricula leading to the bachelor of science degree.

(c) Accrediting applies to day curricula only. Action on evening curricula in which the quantitative requirements differ materially from the usual day curricula has been deterred pending further study by a special subcommittee of the E.C.P.D. Committee on Engineering Schools.

(d) Accrediting applies to the five-year cooperative curricula leading to degrees.

EXHIBIT PRESENTED BY AMERICAN ENGINEERING COUNCIL AT THE THIRD WORLD POWER CONFERENCE, HELD IN WASHINGTON, D.C., SEPTEMBER 7–12, 1936

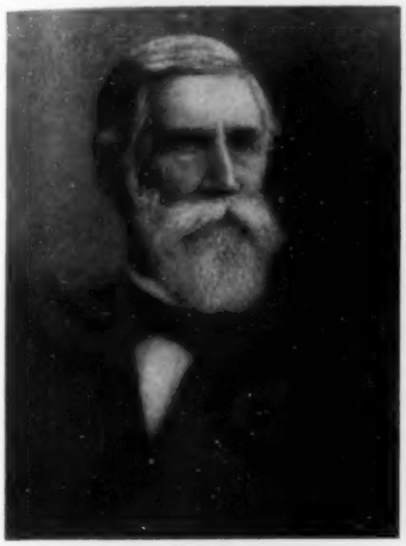
The 8 by 12-Ft Map in the Background Shows the Locations of the National Engineering Societies and Their Local Sections, the State Engineering Societies, and the Independent Local Engineering Groups. Grouped Around the Central Feature Are Panels Giving Pertinent Facts About Many of These Organizations

Early Presidents of the Society

In this series of brief biographies of the early presidents of the Society, every effort is made to appeal to the casual reader as well as to the serious student of engineering history. To achieve this aim the cooperation of many persons is necessary. Anyone knowing personal incidents in the lives of these men, or possessed of photographs of engineering works with which they were connected is requested to communicate with Society Headquarters. The next three articles will be devoted to William Milnor Roberts, Albert Fink, and James Bicheno Francis, in the order named.

VIII. Ellis Sylvester Chesbrough, 1813–1886
President of the Society, 1877–1878

By the middle of the nineteenth century, the little settlement on the southwest shore of Lake Michigan had become a thriving young city. There, at the head of navigation on the lower four lakes, the manufactures of the East and the raw products of the West changed hands in ever-increasing quantities. From the standpoint of commerce, the location was ideal.



Ellis Sylvester Chesbrough
Eighth President of the Society

From the standpoint of healthfulness, however, the site of Chicago left much to be desired. Westward from the lake extended a marshy plain, broken only by the channel of a brackish river whose source was on a dead level with its mouth. As the population grew, the city was in danger of being stifled by its own by-products. The effluvia of the packing plants and of household wastes, and the sodden filth of the soggy streets, were at times almost unbearable. Cholera swept the city in 1849 and again in 1854. Without the aid of the sanitary engineer, the limit of municipal growth might soon have been reached.

Perhaps because it had come nearest to reaching the limit of endurance, Chicago was the first city in the country to construct a sewerage system worthy of the name. A few years later it added an improved water supply system that involved an unusual feat of engineering. Meanwhile it began to fill the lowlands, eliminating the stagnant ponds; it improved its streets and built parks. By 1870 the "Garden City" had undergone an astounding transformation. And a major share of the credit for that change may fairly be given to one man—a mild-mannered but persistent engineer, Ellis Sylvester Chesbrough.

Chesbrough was born near Baltimore, July 6, 1813. When he was but nine years old his formal education was ended abruptly by his father's failure in business, and at fifteen he found work for himself as chainman on a Baltimore and Ohio survey party. He was of delicate physique, and it is said that only his strong will carried him through the hardships of that work. His chief was impressed by his intelligence, patience, and cheerfulness, and after a year occasionally entrusted him with a party of his own. He became an assistant engineer at seventeen, and continued in railroad work until 1842.

In that year every railroad construction project in the country came to a standstill—an aftermath of the panic of 1837. Chesbrough, as well as many another engineer throughout the country, was out of a job. He improved his time by learning the practical use of tools, in the shops of the Providence and Stonington. As the depression continued he decided to take up farming, and bought land next to his father's in Niagara County, N.Y. This venture was unsuccessful, however, and at the first opportunity he returned to his profession, working on railroads in New England.

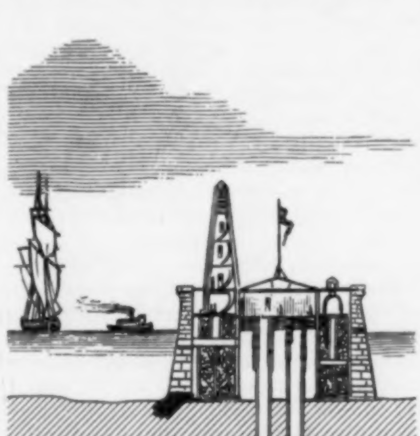
There he made the acquaintance of the water commissioners of Boston, and in 1846 they surprised him with an invitation to become chief engineer of the western division of that city's water works. That invitation, which proved to be the turning point of his career, he all but refused because of his lack of knowledge of hydraulics. The commissioners assured him, however, that John B. Jervis, who had designed the work then under construction, would continue with him as consultant, and he finally accepted. In 1849 he completed the Lake Cochituate supply; in 1850 he became sole commissioner of the water works; and in 1851 he was appointed the first city engineer of Boston. In memory of his work in that capacity, the name of Chesbrough Road was given to one of Boston's streets in 1933.

In Europe, the study of sewage disposal was given an impetus by London's Metropolis Water Act of 1852. Chesbrough followed the continental developments closely—nothing of importance was being done along such lines in America—and in 1855 he was selected by the sewerage commissioners of Chicago to design a system for that city.

There were several possibilites. The sewage might be conducted into artificial reservoirs, "to be thence pumped up and used as manure." It might be diverted into the Illinois River by lowering and enlarging the barge canal. It might be turned into the Chicago River directly, to flow thence into the lake. The first scheme Chesbrough rejected because of the uncertainty that there would be enough demand for the manure to pay for distributing it, and because of "the great evil" that would result from a failure of the pumps. The second scheme he dismissed on the grounds that the enlargement of the canal was "too remote a contingency to be relied upon for present purposes," and the third was adopted as being the cheapest and surest.

The area to be sewered was a rectangle bounded on the north by Division Street, on the south by North Street, and on the West by Reuben Street. Within this area the river branches to the north and south, and the south branch was to receive the major load. In order to create a sufficient current therein to carry the sewage into the lake, Chesbrough included in his plan a canal along North Street, equipped with a pumping engine, which was to supply a constant stream of lake water to the river. "Clean water in sufficient quantities," he said, "would be the best deodorant it would be possible to obtain." Unfortunately, for lack of funds this feature was omitted.

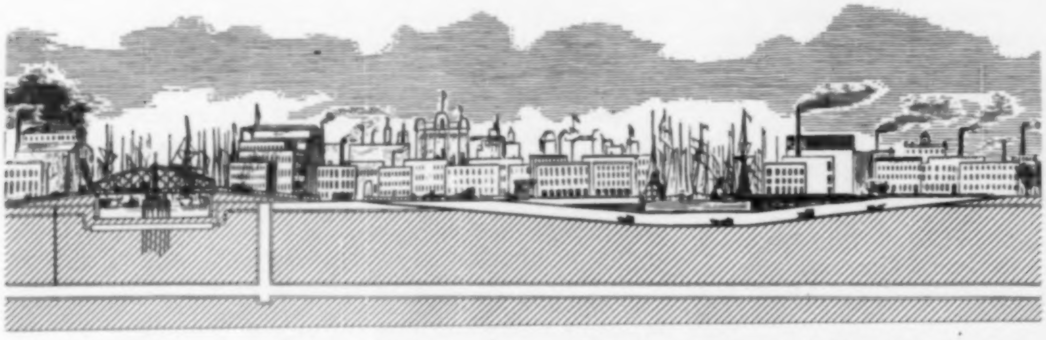
The state of the art of sewer design in 1855 is well illustrated by the following extract from Chesbrough's report: "It is recommended that all the main sewers be circular, 5 ft in diameter [with one exception]. The mains are to be built 8 in. thick, of brick; . . . the smaller ones of earthenware glazed pipes, if they can be obtained in sufficient quantites." It is also interesting to note his comment on separate systems: "It is said by very respectable authority . . . that to drain a city perfectly, a system of sewers should be constructed for the surface water, separate from that provided for other kinds of drainage." This arrangement was impracticable at the time, but he suggested that if the sale of sewage as fertilizer



A Water Works Intake That Set a Precedent in 1866
The Crib in Lake Michigan, Two Miles from Shore

ever became worth while, small sanitary sewers could be constructed cheaply without interferring with the original layout. Actually the first separate system in America was built in 1880.

Because of the flatness of the terrain, Chesbrough laid the sewers on a grade of only 1:2,500, a slope several times as flat as the "best



CHICAGO, 1874: A SECTION ALONG LASALLE STREET, SHOWING CHESBROUGH'S VEHICULAR TUNNEL UNDER THE RIVER AND, AT A LOWER ELEVATION, THE WATER-SUPPLY TUNNEL

practice" of the day in Europe considered feasible. To avoid trouble, he designed a system of flushing mains, but it was never built. Hand-cleaning and occasional flushing from hydrants apparently sufficed. Even with the flat slopes, the tops of the sewers were so close to the surface that the street grades throughout the city had to be raised an average of 18 in.

The sewerage commissioners sent Chesbrough to Europe after the work was under way, to study practice there and work out improvements in his system. His report was made in 1858, and almost 30 years later it was still in demand "as a standard contribution to which very little new information has been added by later writers."

Dumping the sewage into the river relieved the situation temporarily, but the city grew more rapidly than had been anticipated. In 1860, more than 300,000 cattle and hogs were killed and packed, and all the offal was passed into the sluggish stream. The commissioners recommended the enlargement of the barge canal to reverse the flow of the river, but their suggestion "was not deemed necessary." Five years later, however, it was adopted, and the enlargement was completed in 1871. (The present sanitary canal dates from 1900.)

Meanwhile, the sewage poured into the lake, and "a short distance north of the mouth of the river the engines of the old water works were at work, pumping this foul liquid into the reservoirs, from whence it found its way to every family in the city." (*Tunnels and Water System of Chicago*, J. P. Wing and Company, 1874.)

Obviously, the intake must be extended further into the lake. Chesbrough, now city engineer, recommended a tunnel, and promptly met with opposition. Such a thing had never been attempted; it was a wild dream, a foolhardy scheme. Why not lay a pipe on the bed of the lake? Chesbrough stuck to his guns, and won out. Work began in 1863.

The tunnel was two miles long, and ran mostly through blue clay. The lake crib was built on shore as a caisson, towed to place, and sunk with ballast. Excavation was carried on from both ends, and when the tunnel was holed through, in 1866, the lines met within an inch.

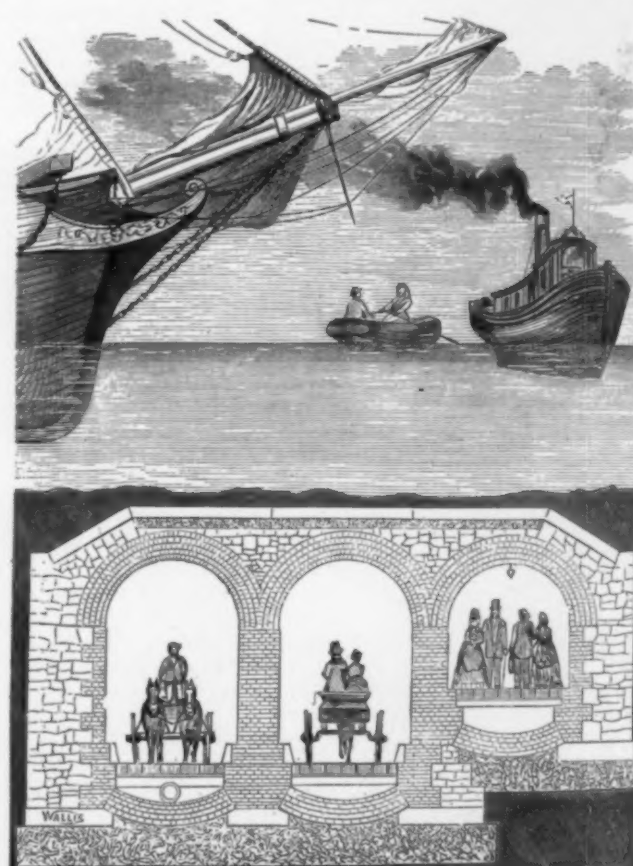
"The width of the tunnel, when bricked up, was . . . 5 ft, and its clear height 5 ft 2 in." (Wing, op. cit.). Two miners were all that could work at the face, and the brick masons followed them as fast as they advanced. From 14 to 20 ft was considered great progress for 24 hours. To provide ventilation, a large steam bellows was placed at the mouth of the shaft and connected with a perforated suction pipe that extended to near the working face. Mule cars were used to haul away the spoil and bring in the brick and mortar.

So successful was this project that similar intake arrangements soon began to be adopted by other cities on the Great Lakes and along the larger rivers. A second tunnel, 10 ft in diameter, was begun at Chicago in 1872, and two years later a tunnel was driven under the city, to a point on the river near 22d Street, to insure an adequate water supply for the "remote districts."

About this time Chesbrough also constructed two vehicular tunnels under the river, at LaSalle and Washington streets. This work was done in open cut, between cofferdams, and apparently presented no unusual problems.

Among the projects in other cities with which Chesbrough was connected between 1855 and 1879, two deserve especial mention. He was in charge of the first attempt at river tunneling in the United States—at Detroit, in 1872. The object was to connect the Michigan Central with the Great Western of Canada. The operations were "carried forward energetically from both shores, but the river broke through so many times that the projectors became discouraged and abandoned the work the next year" (Kirby and Laurson, *Early Years of Modern Civil Engineering*). The river was not successfully pierced at that point until 1909. Chesbrough also, with Moses Lane, proposed in 1879 the system of sewerage for Boston that was constructed a short time later.

His last professional engagement was on the New Croton Aqueduct at New York. Together with the chief engineer, he prepared the plans for the aqueduct, and in 1882 he was sent to France and Spain to gather data for use in the design of the Quaker Bridge



CHESBROUGH'S TUNNEL AT LASALLE STREET, CHICAGO, WAS OPENED TO THE PUBLIC ON JULY 4, 1871

Three Months Later It Was Put to an Unexpected Use as a Refuge for Hundreds of Persons Fleeing the Great Fire

Dam, which was to be "of unprecedented magnitude" (*Engineering News*, August 21, 1886). While abroad he contracted an illness from which he never fully recovered, and after presenting his report in 1883 he retired. He died in Chicago, August 18, 1886.

Chesbrough's contributions to the development of the three oldest engineering societies in the United States was unique. He was chairman of the group that organized the Boston Society of Civil Engineers, and "should be given much of the credit for the inception of the idea and for the successful carrying out of the plan . . . ; in the American Society of Civil Engineers he served as president and became an honorary member; and in the Western Society of Civil Engineers he held the office of president for many years." ("Professional Biographies of the Founder Members of the Boston Society of Civil Engineers," by John B. Babcock, 3d, M. Am. Soc. C.E., in *Journal, Boston Soc. C.E.*, July 1936.)

"Though owing little to early teaching, he mastered, by close and unremitting study, the entire field of general literature, as well as that of his chosen profession" (*Engineering News*). For a quarter of a century the recognized head of sanitary engineering in this country, he was nevertheless "extremely modest in the expression of his opinions . . . [and] careful to avoid any appearance of the assumption of superiority."

The writer of his Memoir adds (*Proceedings*, Vol. 15, 1889):

"Slow in forming an opinion and always endeavoring to ascertain all the practical as well as theoretical information which might possibly aid in a correct conclusion, he was, while eminently courteous and mild in manner, practically immovable from an engineering position which he had finally taken. . . . His standard of professional honor was extremely high."

[The assistance of Charles W. Sherman, M. Am. Soc. C.E., in supplying basic information for this biography is gratefully acknowledged.]

Board Enjoys Record Attendance

FOR THE FIRST TIME in many years the Board of Direction, when it assembled in Pittsburgh in October, boasted a 100 per cent attendance. Every Director and Vice-President was on hand, also the two latest Past-Presidents, the Secretary, and the Treasurer of the Society. President Mead was in the chair; he has not missed a meeting since he took office.

Of the deterring factors, sickness has often played a major part. Unavoidable attendance on business matters, however, has been the major contributing cause. During the past few years engineers could hardly forego the returns from outside engagements, and attendance was in many instances contributed at real sacrifice.

On a number of occasions the roll call showed that a perfect record was almost within reach. It was therefore a real satisfaction to the entire Board when this goal was finally attained at Pittsburgh.

This unusual event calls attention once more to the efficient and faithful service of 26 busy men. By their efforts the progress of the Society is measured. An idea of their deliberations at this meeting may be gained from the Secretary's abstract of the minutes elsewhere in this issue.

Prizes and Medals for Papers in TRANSACTIONS

ON October 11, 1936, by action of the Board of Direction, medals and prizes were awarded for papers appearing in Vol. 100 of TRANSACTIONS. The papers for which these awards were given and their authors are as follows:

Norman Medal—To Daniel W. Mead, President and Hon. M. Am. Soc. C.E., for his paper entitled "Water-Power Development of the St. Lawrence River."

J. James R. Croes Medal—To Wilbur M. Wilson, M. Am. Soc. C.E., for his paper entitled "Laboratory Tests of Multiple-Span Reinforced Concrete Arch Bridges."

Thomas Fitch Rowland Prize—To A. V. Karpov and R. L. Templin, Members Am. Soc. C.E., for their paper entitled "Model of Calderwood Arch Dam."

James Laurie Prize—To Paul Baumann, M. Am. Soc. C.E., for his paper entitled "Analysis of Sheet-Pile Bulkheads."

Collingwood Prize for Juniors—To Clinton Morse, now Assoc. M. Am. Soc. C.E., for his paper entitled "Renewal of Miter-Gate Bearings, Panama Canal."

Following its usual custom, the Society will make an official presentation of these prizes at the first morning session of the Annual Meeting, that is, on January 20, 1937. Brief biographical sketches of the prize winners will appear in a forthcoming issue of CIVIL ENGINEERING.

Society Badges for Christmas Gifts

NO, IT IS really not too early to begin thinking about Christmas. For some of the most welcome gifts require a little advance planning. This is true of Society badges, which must be ordered by December 1 if delivery is desired before Christmas. The inevitable increase in orders at this time of the year makes the setting of this date necessary in order to avoid disappointing many who may be counting on a handsome blue-and-gold pin with which to surprise father, husband, or brother on Christmas morning.

A Society badge makes an ideal gift, because it is distinctive, valuable, and personal. There is no member of the Society, or of its Student Chapters, who will not be pleased by it. And it is sometimes difficult to introduce a note of variety in one's gifts to the men of the family.

In ordering a Society badge for a Christmas gift, the recipient's grade in the Society must be taken into consideration. The badge for Honorary Members, Members, Associate Members, and Affiliates is a rich shade of blue enamel on solid 14-carat gold, the gold showing in the lettering and as a border around the shield. This costs $5.00, including the cost of engraving with the member's name and grade in the Society. The pin for Juniors ($2.00), which is of 8-carat gold, is similar in shape and design but has a white border; and the pin for members of Student Chapters ($1.00), which is gold filled, likewise has a white border, but is maroon where the other pins are blue. The Junior and student pins are not engraved. Badges may also be had in the form of fobs or charms for watch chains, if desired. All pins have safety catches.

Of course no member of the Society may possess more than one badge at a time. If the intended recipient of this gift has never before had a badge the order will not be questioned. However, if he has had one and it has been lost, the order should be accompanied by a statement to that effect. All orders should be sent to Society Headquarters, 33 West 39th Street, New York, N.Y.

Activities of Engineering Foundation

PROGRESS on a number of projects during the third quarter of 1936 is reported by the Engineering Foundation. Manuscript for the eighth book to be published by the Alloys of Iron Research has gone to the printer. This volume is entitled "Alloys of Iron and Carbon: Properties." The research on pure iron electrodes for welding was terminated by expiration of the agreement with Lehigh University, and final reports are in progress of preparation. The welding research committee continued the work of its subcommittees on literature, on fundamental research, and on industrial research, and the last named reported progress in securing financial and other contributions from industries. At the University of Pittsburgh, work was completed on the study of creep and relaxation of metals, and the final report is being written.

Three new series of long-time tests on plastic flow of concrete were begun at the University of California, and the Foundation continued collecting information to assist it in determining the feasibility of the proposed fundamental research program in concrete.

Long-radius flow nozzles were studied in several laboratories, with a view to providing a more economical and convenient means for precise measurements of large quantities of liquids and gases, as in efficiency tests of steam and hydraulic power installations.

In the matter of non-technical projects, the Foundation reports that the Engineers' Council for Professional Development has completed collecting information for accrediting schools in the New England and Middle Atlantic states, and has begun similar work in other sections; and that the report of the Personnel Research Federation on "Forms of Employer-Employee Cooperation" is ready for publication.

On October 8 the Foundation elected officers and made committee appointments for the ensuing year. Frank Malcolm Farmer and D. Robert Yarnall were chosen as chairman and vice-chairman, respectively. Alfred D. Flinn, M. Am. Soc. C.E., continues as director and secretary. The executive committee includes Messrs. Farmer and Yarnall, Otis E. Hovey, M. Am. Soc. C.E., A. L. Queneau, and Walter I. Slichter. Thaddeus Merriman, M. Am. Soc. C.E., continues as the Society's representative on the research procedure committee.

Preview of Proceedings

By HAROLD T. LARSEN, *Editor*

A variety of interesting topics will be treated in the November issue of "Proceedings." Papers on the following subjects have been scheduled for that number: Stresses around circular holes in triangular dams and buttresses; the construction and testing of hydraulic models at the Muskingum watershed project; the economic diameter of steel penstocks; and reclamation as an aid to industrial and agricultural balance.

Stresses Around Circular Holes in Triangular Dams and Buttresses

A brief but valuable mathematical paper, dealing with "Stresses Around Circular Holes in Dams and Buttresses" is being presented, in the November issue, by I. K. Silverman, Jun. Am. Soc. C.E. It applies especially to inspection galleries in gravity dams, or open spaces through buttresses in multiple arches, or the Ambursen type of dam. The method is generalized by assuming that, although openings in dams or buttresses are not always circular, the intensity of stress around such openings may be analyzed by considering them circular. Other assumptions made by the author are that the material is homogeneous and elastic and that it follows Hooke's law. With the constructive discussion, which is confidently expected on this paper, there will be added a new and interesting contribution to the design of dams.

Construction and Testing of Hydraulic Models, Muskingum Watershed Project

In recent years, technical journals have been replete with theoretical papers on models, including the theory of similitude and the reporting of test results observed from models. The apparently simple question of how to go about building models has been answered piecemeal in a number of hydraulic laboratory bulletins and in a number of technical papers, but generally speaking, there seems to be no readily available material that presents this important phase of the problem as a unified treatment. George E. Barnes, M. Am. Soc. C.E., and J. B. Jobes, Jun. Am. Soc. C.E., present a useful paper of this type entitled "Construction and Testing of Hydraulic Models, Muskingum Watershed Project." It will be remembered that the Muskingum project was the subject of a special regional meeting at Zanesville, Ohio, on October 4, 1935. The papers read at that meeting were published in CIVIL ENGINEERING for January 1936. A very brief abstract of the present paper was published at that time.

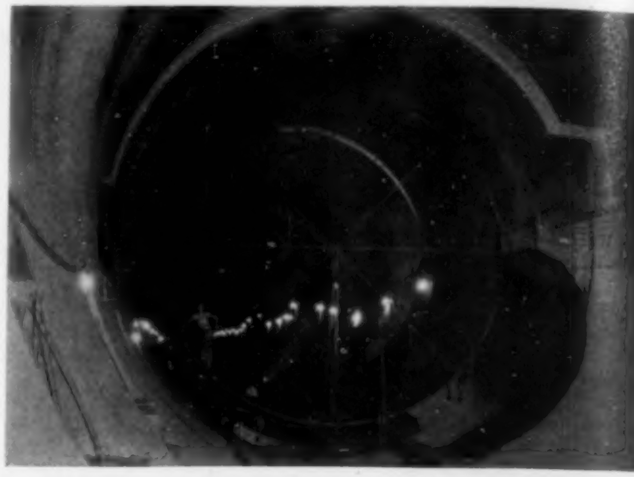
The paper now to be presented for full discussion is complete and fully revised to meet the standards of a PROCEEDINGS paper. An engineer who suddenly has to construct hydraulic models should be able, by reference to this paper, to gain an intimate insight into the problem involved. For more experienced engineers, the paper will commend itself as a convenient check list. In this sense, it seems the duty of every qualified engineer to contribute from his experience whatever seems desirable for improvement.

Economic Diameter of Steel Penstocks

A set of curves for use in estimating the effect of load factor on the quantity of power absorbed in friction and other hydraulic losses in water conduits, such as penstocks and tunnels carrying water for hydroelectric power plants, is presented in the November issue under the title "Economic Diameter of Steel Penstocks" by the late Charles Voetsch, M. Am. Soc. C.E., and Mr. M. H. Fresen, of the U. S. Bureau of Reclamation at Denver, Colo.

Unfortunately Mr. Voetsch died on February 7, 1935, several months before the paper was submitted to the Society for consideration. Discussion on this paper, therefore, will be answered by his co-author, Mr. Fresen. A memoir of Mr. Voetsch, written by J. L. Savage, M. Am. Soc. C.E., has been printed in the current Volume 101 of TRANSACTIONS, and reprints are now available for free distribution to a limited number of interested friends.

The method of attack presented in the paper is the same as that used by previous writers, except that the present authors include



PENSTOCK SECTION, 30 FT IN DIAMETER, BOULDER POWER PLANT

the effect of hydraulic losses other than friction, and they use the Scobey formula instead of some of the early formulas for friction losses. The authors also consider the annual load factor somewhat along the lines followed by Creager and Justin. The equations developed are general, and are intended to determine the economic size of a penstock with a uniform diameter, for a hydroelectric power plant.

Reclamation as an Aid to Industrial and Agricultural Balance

In January 1931 the Society authorized the creation of an Engineering-Economics and Finance Division to supply its members with an avenue of expression in a broader field of professional engineering. This step has served to encourage the civil engineer, to concentrate on this subject of engineering-economics, as witnessed by an increasing number of papers appearing in the publications of the Society.

A paper of timely as well as lasting interest will appear in the November issue of PROCEEDINGS under the title "Reclamation as an Aid to Industrial and Agricultural Balance," by Ernest P. Goodrich and Calvin V. Davies, Members, Am. Soc. C.E. This paper deals with the broad subject of technological unemployment, decentralization of industry, and a proper balance between industry and agriculture in a given state or region. The authors have developed their subject in some detail presenting factual data from the experience of two industrial organizations that have had experience in industrial cooperative projects.

AN INDUSTRIAL COOPERATIVE GARDEN PROJECT

They have studied the problem from three viewpoints: (1) the decentralization of industry; (2) the diversification of labor; and (3) the coordination of industry and agriculture. This has the effect of dividing the paper into three rather well-defined parts. Part 1 is devoted to a review of the basic principles of

each of the three factors, and in Part 2 the principles are applied broadly to an actual problem, the Central Valley project in California. Finally, the potential benefits discussed in Part 2 are further illustrated in Part 3, by a more detailed analysis that demonstrates the possibilities of coordination of industry and agriculture with the Madera Irrigation District, in California, which is one of the beneficiaries of the Central Valley project.

Five Prominent Engineers Elected to Honorary Membership

HONORARY MEMBERSHIP, the highest award in the power of the Society to bestow, has just been conferred upon Alex Dow, George Herrick Duggan, Robert Hoffmann, Joseph Barlow Lippincott, and John Alexander Low Waddell. The election took place at the Pittsburgh meeting of the Board of Direction.

The Constitution of the Society prescribes that Honorary Members shall be chosen from among "persons of acknowledged eminence in some branch of engineering or the sciences related thereto." Not more than five may be named in any one year, and at no time may there be more than one Honorary Member for every three hundred Corporate Members. The present additions bring the list of living Honorary Members to twenty-four.

Alex Dow has been president of the Detroit Edison Company since 1912, and is well known for various innovations in the field of power generation and distribution. He has been a member of the Society since 1906 and is a former president of the American Society of Mechanical Engineers. Mr. Duggan is president of the Dominion Bridge Company, Montreal, vice-president of the Royal Bank of Canada, and a director of several important industrial and financial corporations. He has been a member of the Society since 1905 and is the oldest living past-president of the Engineering Institute of Canada. Mr. Hoffmann entered the Society in 1901 and was a Director in 1932. He has been in the service of the city of Cleveland for 43 years, for more than half of that time in the capacity of chief engineer. His present designation is consulting engineer on public works. Mr. Lippincott, a consulting engineer in Los Angeles, has had a prominent part in the development of many of the outstanding flood-control, irrigation, and water-supply projects of the West, particularly in California. He has been a member of the Society since 1899. Dr. Waddell, of the firm of Waddell and Hardesty, has built bridges on four continents and is internationally recognized as one of the outstanding engineers in his field. He became a full member of the Society 55 years ago.

More complete accounts of these noted engineers will appear in a later issue. The actual award of the certificates of honorary membership will be an important feature of the opening session of the 1937 Annual Meeting in New York.

Appointments of Society Representatives

DANIEL W. MEAD, President Am. Soc. C.E., will serve as one of the Society's representatives on the John Fritz Medal Board of Award for the four-year term, October 1936 to October 1940.

THADDEUS MERRIMAN, M. Am. Soc. C.E., and JOHN R. BAYLIS, Assoc. M. Am. Soc. C.E., have been reappointed Society representatives on the Sectional Committee on Portland Cement of the American Society for Testing Materials.

ALBERT F. REICHMANN, M. Am. Soc. C.E., has accepted an appointment as one of the Society's representatives on the Washington Award Commission.

ARTHUR N. TALBOT, Past-President Am. Soc. C.E., has been appointed a Society representative on the Sectional Committee on Portland Cement of the American Society for Testing Materials to fill the vacancy caused by the death of A. E. PHILLIPS, M. Am. Soc. C.E.

News of Local Sections

DAYTON SECTION

The Dayton Section's first meeting of the season took the form of a luncheon, given at the Engineers' Club on September 28. There were 18 members and 13 guests present. After a brief business discussion J. S. Cutler, regional conservator for the district, was introduced. Mr. Cutler gave a talk on the subject of soil conservation, informing his audience of the causes and cures of soil erosion and explaining the steps being taken by the U. S. Soil Conservation Service to cope with the problem of erosion.

GEORGIA SECTION

A luncheon meeting of the Georgia Section was held in Atlanta on September 14. A motion was passed, congratulating E. D. Rivers on his election as governor and promising him cooperation in matters pertaining to public works and state planning. Then the speaker of the occasion, O. H. Stablei, was heard. Mr. Stablei discussed the subject of forestry work in the Atlanta region, commenting on the decentralized organization of this work and describing the handling of fire prevention.

MILWAUKEE SECTION

On May 6 a joint meeting of the Milwaukee Section and the local branch of the American Institute of Electrical Engineers was held on the campus of Marquette University. Sixteen members of the Section were present at the meeting, which was preceded by a dinner at the LaSalle Hotel for a number of the officers of both groups. The feature of the evening was a talk by William Monroe White, manager and chief engineer of the hydraulic department of the Allis-Chalmers Manufacturing Company, whose topic was Boulder Dam. The address was illustrated by lantern slides, showing the entire construction operations.

SAN DIEGO SECTION

There were 15 present at the September meeting of the San Diego Section. The first number on the program was a lecture by Dean Blake, meteorologist of the San Diego station of the U. S. Weather Bureau, who explained by means of charts the causes of San Diego's mild climate. Next three reels of motion pictures were enjoyed through the courtesy of the Chevrolet Motor Company. These pictures showed how the cooling system of an automobile is designed and described the development of the hydraulic brake.

SOUTH CAROLINA SECTION

The annual summer meeting of the South Carolina Section took place at the Ocean Forest Hotel at Myrtle Beach, S. C., on July 10. This meeting, which was held in conjunction with a meeting of the South Carolina Society of Engineers, attracted an attendance of 18. The feature of the occasion was a general discussion on the future activities of the Section.

TACOMA SECTION

There were 19 present at a dinner meeting of the Tacoma Section, which took place in the Tacoma Hotel on September 14. During the business session J. P. Hart, president of the Section, reviewed the summer's activities, and W. A. Kunigk discussed his trip to the Annual Convention in Portland. E. L. Warner, chairman of the program committee, then introduced the speaker of the evening, H. F. Faulkner, of the Seattle city engineer's office, who described the present status of the Grand Coulee Dam project. This was followed by a talk by Walter Ryan, who gave a brief résumé of a recent visit to the project, and a round-table discussion was the concluding feature.

TENNESSEE VALLEY SECTION

At the fall meeting of the Tennessee Valley Section the following officers were elected for the coming year: E. D. Burchard, president; R. L. Maynard, vice-president, Asheville area; Henry Fruend, vice-president, Knoxville area; Gerald R. Kavanagh, vice-president, Chattanooga area; and Robert Olds, vice-president, Muscle Shoals area. Hal H. Hale was reelected secretary-treasurer.

ITEMS OF INTEREST

Engineering Events in Brief

Civil Engineering for December

Among the articles scheduled for the December issue is one by E. A. Kemmler, M. Am. Soc. C.E., former director of public service of the city of Akron, Ohio, on publicizing municipal services. Mr. Kemmler's paper has as its background the 93 monographs prepared by the Akron public service department and distributed each week not only to the local chamber of commerce, to schools and libraries, and to individuals, but also to newswriters for local newspapers and engineering periodicals. In this way public support was enlisted for many worth-while engineering projects. Incidentally, the important activities of engineers in public service were brought before the citizens thereby.

The matter of the sufficiency of stream flow to justify the St. Lawrence power development project as now contemplated is opened to question anew in a paper by Theron M. Ripley, M. Am. Soc. C.E., consulting engineer of Buffalo, N.Y. Mr. Ripley's study leads him to the conclusion that the present slow but continuous fall of the Lake Ontario and St. Lawrence River water levels, coupled with similar recorded trends in the past, limits the useful life of the project to not more than 50 years.

If space permits, there will be included in the December number a second paper on the life and works of Thomas Telford, pioneer in bridge, canal, and road construction, by J. F. Baker, Assoc. M. Am. Soc. C.E., professor of civil engineering at the University of Bristol, England, and John Armitage. This paper is concerned principally with construction of the Caledonian Canal in Scotland and the Gotha Canal in Sweden, representing two of Telford's largest and most important engineering works.

Wise and Otherwise

Among Professor Abercrombie's acquaintances there are two who do not always tell the truth. A lawyer friend of the Professor wished to use them as his witnesses in a pending case, but was uncertain whether under the circumstances such use would be wise. By reputation, one man spoke the truth 3 out of 4 times, the other 3 out of 5. In his dilemma, the lawyer consulted Professor Abercrombie, whose advice in such matters he valued very highly. The Professor at first expressed himself as against the plan. In the course of the conversation, however, it developed that the critical question to be answered was not whether the witnesses would (merely) tell the truth, but whether they would return the same answer to a question which could only be answered "yes" or "no." Under these conditions, the Professor favored their employment. What was the mathematical reason why he reversed his earlier opinion?

October's problem involved the proper number of sheep required to eat all of the grass initially in a 6-acre pasture together with all that should grow there within a period of 6 weeks. The relevant facts were (1) 3 sheep will eat in 2 weeks all the grass initially on 2 acres of land and all the grass which grows there in that time, and (2) 2 sheep will eat in 4 weeks all the grass initially on 2 acres of land and all the grass which grows there in that time.

In solving this problem, it is understood, of course, that the quantity of grass on each acre is the same when the sheep begin to graze and also that the rate of growth is uniform. From the relations given it can readily be determined that when the grazing starts there is 4 weeks' growth on each acre, and that each sheep eats each week the grass which grows on 2 acres during that week. The solution can then be completed easily, the answer being 5 sheep.

Suggestions for other problems for Professor Abercrombie's column, accompanied by solutions, may be addressed to the editor. Solutions should preferably be sent in separate enclosed envelopes.

Glass Pipe Carried Water to Union College in 1840's

By Russell A. Hall

Member American Society of Civil Engineers
Associate Professor of Civil Engineering, Union College, Schenectady, N.Y.

While regrading a garden on the Union College campus at Schenectady, N.Y., in the summer of 1934, workmen uncovered a short length of glass tubing encased in mortar. The piece undoubtedly had once been part of an underground conduit. In the fall of 1935, while digging

Specimens of Glass and Clay-Tile Water Conduit Uncovered on Union College Campus, Schenectady, N.Y.

a trench on another part of the campus, the workmen encountered another conduit made of burned clay tile encased in mortar. Both are shown in the accompanying illustration.

It has been impossible to determine accurately the historical origin and use of these conduits, but in the historical notes appended to the annual reports of the Bureau of Water of the City of Schenectady, the following has been reprinted for years without its exact origin being known:

"In the early 40's Union College had a private water system: A hydraulic ram, fed by a spring located somewhere above Nott Terrace and north of Vale Cemetery, forced water through a glass pipe to the College. This glass pipe was about one inch in diameter and covered with a cement or mortar jacket about two inches thick."

The statement is probably correct. The college buildings adjacent to the location of the pipe were built about 1814 on an elevation above the city of Schenectady, and in the 1840's were a considerable distance outside the built-up section. The city itself had no water works until 1872. A pipe line about two thousand feet long, on approximately a level grade, would have been required to bring the water from the vicinity of Vale Cemetery to the Union College campus.

Evidently the glass pipe was the supply main and the clay tile were the distributing conduits built by Union's ingenious and ambitious president, Dr. Eliphalet Nott, to supply the needs of the faculty and student occupants of the early college dormitories. The length of the individual pieces of glass tubing is unknown, but the specimen found included a joint. The tubing was drawn thick at one end with a slight internal taper, and the other end was drawn thin and tapered to fit inside it. Plaster of paris was used between the two tapered surfaces to form a seal. The tubing was encased in a cylindrical shell of lime or cement mortar from an inch to an inch and a half thick, which in its present state is very friable. The individual clay tile were about a foot long, with a cylindrical tongue about an inch in length projecting from one end and a cylindrical socket formed to receive the tongue in the opposite end. The joints were sealed with plaster and the pipe encased in a mortar cylinder afterward. It would be interesting to learn whether this type of construction was used elsewhere in early water-works practice.

A Model of a Rapid Sand Filter Plant

By RANALD V. GILES

ASSOCIATE MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS
ASSISTANT PROFESSOR IN CIVIL ENGINEERING, DREXEL INSTITUTE OF TECHNOLOGY, PHILADELPHIA, PA.

A WORKING model of a rapid sand filter plant, built last year at the Drexel Institute of Technology, has proved to be a valuable aid in teaching the fundamentals of filter plant design. The apparatus includes mixing chambers, a coagulation basin, and a filter unit with a rated capacity of 2 gal per min. The cost of materials did not exceed $35, and the parts were fabricated and assembled in the shops of the Institute under the direction of the writer.

Water enters the mixing chambers (shown at the right of the photograph below) through a $^1/_2$-in. pressure pipe. In the first chamber artifical turbidity and color may be applied to simulate a raw water, and in the second chamber a coagulant may be added. The treated water travels thence through the remaining mixing chambers and a baffled coagulation basin to the filter. A perforated pipe underdrain system collects the water and conveys it to the point of sampling and to the discharge pipe line. Backwashing the filter is accomplished by using tap water through a $1^1/_4$-in. line. Regulation of all rates of flow can be made from one point by means of gate valves, and therefore no float valves have been installed to control flow or water levels. A sampling tap and a gage to measure loss of head are located on the filter effluent line close to the wall of the unit. The entire model is mounted on two tables in the sanitary engineering laboratory and occupies a space 6 ft long by $2^1/_2$ ft wide.

The tank which provides for mixing and coagulation is 48 by 30 in. in plan by 12 in. deep. It consists of 10-gage steel plates welded together with a $^1/_2$-in. angle welded around the top for stiffness. Baffles and partitions are of 22-gage galvanized iron. The mixing chambers as now arranged serve to illustrate "over-and-under" and "around-the-end" methods of mixing. Later, one or more alternate designs, including mechanical mixers, will be substituted.

The arrangement of baffles in the coagulation basin can be varied for experimental purposes by the student. With the set-up as illustrated, the retention period is about thirty minutes and the maximum length of travel is approximately 12 ft.

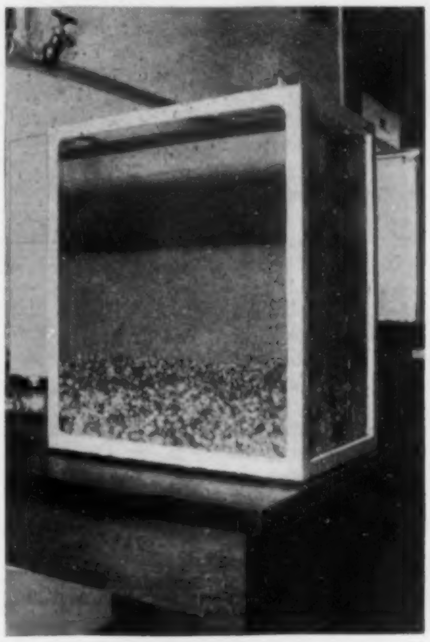
The filter unit consists of the filter proper and a channel box, $8^1/_4$ by 4 by $14^1/_2$ in. high, which performs double duty in carrying treated water to the filter and wash water to the drain. The filter, 9 by 16 in. in plan and 18 in. deep, provides 1 sq ft of sand area. The back and bottom are of 20-gage galvanized iron soldered to the $^3/_4$-in. angle frame, the edges of the bottom plate being bent to form a shallow box. The sides and front consist of $^1/_4$-in. plate glass held in place at the top by small angles and at the bottom by the recess between the angle frame and the box-shaped bottom plate. Aquarium cement made the assembly watertight.

The filter influent is distributed on to the bed by means of two wash-water gutters $4^1/_2$ in. on centers, whose elevation and slope can be adjusted at the front end by means of threaded brass bolts.

Copper tubing is used for the underdrains. The main collector, running from front to back, is 1 in. in diameter. Sixteen pairs of laterals, $^1/_4$ in. in diameter and 1 in. on centers, are soldered to it. Each lateral contains 10 perforations on the under side.

The present filter bed consists of $5^1/_2$ in. of gravel in graded sizes and 6 in. of filter sand. Five valves provide complete flexibility of operation. One controls the inflow to the mixing chambers; two regulate the inflow and outflow of wash water; and two others, the filter influent and effluent. As filtration proceeds, the upper layers of sand become distinctly darker than the lower layers.

In demonstrating the apparatus, artificial turbidity has been obtained with kaolin or Fuller's earth, a small amount of highly turbid water being introduced into the tap water continuously at the entrance to the mixing chambers. Ferrous sulfate and lime produce a heavy floc that forms rapidly. The settling in the coagulation basin is readily observed, and the influent to the filter contains a satisfactory amount of floc.

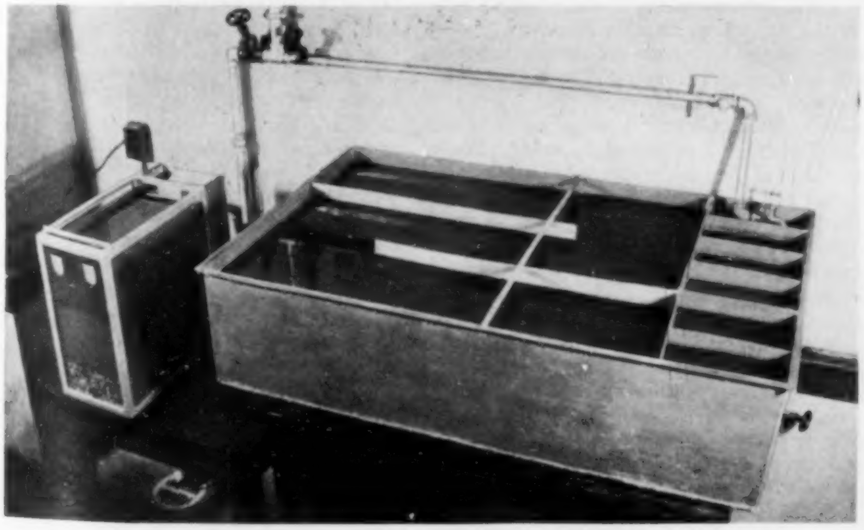


THE FILTER IN OPERATION
A Sand Area of 1 Sq Ft Is Provided

The model provides an opportunity for a wide variety of demonstrations and experiments. The student can test the quality of water entering the basin (raw water), the filter influent (treated water), and the effluent. He can observe the depth of penetration of the material filtered out of the water, and the loss of head through the filter, and can determine rates of flow by volumetric measurement. He can wash the filter bed, noting the cleansing action, the expansion of the sand, and the time required.

In addition to these routine matters, taste and odor control can be illustrated by introducing activated carbon in the coagulation basin or on the filter bed or both. The filter medium can also be varied, and the results with different materials compared. Future plans include illustrating, in the coagulation basin, the purpose and use of a flocculator.

It is the writer's conviction that the model will continue to prove a satisfactory means of clarifying graphically numerous problems of design, treatment, and operation.



A RAPID SAND FILTER PLANT IN MINIATURE
Working Model Used in Teaching Filter Plant Design at Drexel Institute

Why the Engineer?

Abstracted from an Address Before the World Power Conference on September 7, 1936, at Washington, D.C.

By DR. WILLIAM F. DURAND

LELAND STANFORD UNIVERSITY, CALIFORNIA; CHAIRMAN, THIRD WORLD POWER CONFERENCE; FORMER PRESIDENT, AMERICAN SOCIETY OF MECHANICAL ENGINEERS

A SOMEWHAT trifling answer might be found in the reply, because the world has always had the engineer and cannot get along without him. Regarding the first statement, I like to look upon the engineer as, indeed, the oldest representative of the so-called professions—as one of those groups or guilds, the members of which play some specialized part in the advancement of our civilization.

In this sense there has come about, as we know, such a specialized group. Even if we go back to prehistoric times, we find that there have been, in this sense, engineers since the days of the paleolithic age when man first found a way to fashion flint chips into tips for his arrows and spears; or learned how to utilize the potential energy of a distorted elastic system—a strung bow.

Again there have been bridge engineers since the time when some one found a way by fire or flint axe to fell a tree across a stream; or to utilize a wild grape vine to carry his weight from one shore to the other—the far-away prototype of the noble suspension bridges of modern times. And, if we go back to the great prototype of the engineer, we have Prometheus, who in Greek myth first learned how to bring down fire from heaven and subdue it to the service of man.

Enough on this phase. If, now, we turn to the second phase, that the world cannot get along without the engineer, the truth of this is perhaps obvious. At least, the world will not be willing to forego those things which the scientist and the engineer have jointly provided, in the advancement of what we call our civilization.

If, then, we as a group or guild must carry on, we come at once to the heart of our present inquiry. What is the engineer's part in the cooperative enterprise which we call civilization?

The engineer has been defined as one who is concerned with the utilization of materials and the energies of nature in the service of man. In the preamble to the constitution of American Engineering Council, engineering is defined as "the science of controlling the forces and of utilizing the materials of nature for the benefit of man, and the art of organizing and directing human activities in connection therewith."

Thus, obviously, we are specially concerned with the constructive materials of nature and again with the inorganic energies. On the other hand, we are also concerned with the human agencies through which our ends are to be attained.

For our purposes in this brief statement, I should like to make some reference to three phases or aspects under which this broad subject might be considered:

1. The terminal products of the activity of the engineer.
2. The raw materials from which such products are formed.
3. The social and broad humanistic problems which have resulted, at least in large measure, from the work of the engineer.

Regarding the first of these, I shall say only a word. If we consider a period of only 200 years, say from the time of Watt, we have a world made over, at least as to the material content of our civilization. My only point in recalling this phase of the work of the engineer is to emphasize its magnitude and the extent to which it has changed the conditions of life: social, economic, and politic.

Regarding the second of these, having to do with the raw materials comprising primarily constructive materials and energy, by some combination of which this transformation has been brought about, some more extended word may be appropriate. We must view the constructive materials as a bank deposit, not one drawing interest, but one out of which we are gradually and surely exhausting the principal. Only in part can our more important structural materials, e. g., the ferrous compounds, be used over and over. We cannot completely capture the products of disintegration and reconstitute them into useful products. Neither is nature, so far as we can determine, now engaged in the enlargement of her initial deposits. The result is a gradual but continuous loss of our principal; and to that process there is but one end—ultimate exhaustion.

The same is true with our carbon and hydrocarbon deposits used as a source of heat. We are gradually but surely exhausting our coal deposits, and our provision of petroleum and natural gas.

Falling water—that is, water caught up by the sun's heat into the upper air, carried over the high places of the earth, precipitated and caught and allowed to flow through our power-producing mechanisms—is the only source which partakes of the character of an annual dividend. Presumably as long as the sun radiates heat as at present, so long may we count on this seasonal or annual dividend. Only in the case of falling water, among the sources of present practical importance, do we seem to reach out to sources which lie outside the earth itself.

While all this is well enough known, the question may at least be asked whether we, as engineers, have given the facts the weight which their significance deserves. We, in a sense, have appointed ourselves as custodians of these deposits. We cannot evade the responsibility for their wise and effective use. Have we in the past and are we now living up to the full measure of this responsibility? We can hardly, I think, answer in the affirmative.

However, two things may be said in attempted extenuation of our fault. First, for some of these deposits, the quantity is so large that there is no occasion for worry, and in any event, new or substitute sources may be found long before such a condition begins to make itself felt.

But the use of heat in the development of useful work is a one-way street. In order to transform a part of the heat into useful work, we must let down another and larger part from a high level to a low; and once at the low level there is no way of restoration.

Much the same is true with the useful structural materials. Their utilization involves, at least to some extent, progress along a one-way street, marked by the inevitable loss of some part of that which we wish to preserve and use.

Again as an excuse, it may be urged that the economic and wise use of the materials and agencies of nature is only in part the responsibility of the engineer. This is perhaps true, but we, as engineers, can scarcely find here an adequate alibi for failure to share in all efforts directed towards the development of a forward-looking policy governing the use of nature's gifts.

And who is there outside our own guild likely to understand the significance of waste in the use of the gifts of nature? We cannot escape the fact that we are responsible for the wise and economic use of those gifts of nature in the utilization of which we are now engaged. We must take our part in arousing society and our due share in the work of framing, enacting, and enforcing salutary laws and regulations looking to the ends which I have indicated.

May we now turn to a consideration of the social, economic, and political problems which have been an outgrowth of the work of the engineer?

We have already seen that through the cooperative work of the scientist and the engineer, the world has, in a material sense, been made over. Compare the material content of our civilization of the time just preceding James Watt, 200-odd years ago, with the present; or again, that of the period just following the Civil War with that of the present time. Have we made parallel progress in the adaptation of ourselves, especially our nervous and emotional systems, to these new external conditions? We may indeed ask if we have grown in wisdom commensurately.

It would be a brave man, I believe, who would be prepared to assert and defend the affirmative. If we mean by wisdom a sense of values, an appreciation of the distinction between the abiding and the transient, a capacity for effective judgment based on accurate analysis of our problems—then we can hardly say that we are wiser than our fathers or even wiser than those of centuries long gone by. We have enormously more information, but that is a different thing. The displacement of human operatives by mechanical agencies, the tendency towards the concentration of populations in large centers, the problems of capital and labor, the new conditions and agencies of warfare—these are only examples.

Now what is our duty as engineers with

regard to these problems? We cannot evade the responsibility to take our due share, even the lead, in the study of the problems which our own activities have in a large measure developed.

What I am urging is a quickened sense in the engineer, of his responsibilities, not alone in a purely professional sense, but as a citizen of the world; a responsibility in the fulfillment of which he will take part in the earnest study of social, economic, and political problems, to the end that we may attain a better balance between the material content of our present-day civilization and the uses which we are making of it.

Brief Notes from Here and There

The second international congress of the International Association for Testing Materials will be held in London, England, April 19–24, 1937. Its object is to obtain international cooperation in the study of materials, and to provide facilities for the exchange of views on all matters related to the subject. Approximately 150 papers have already been promised, and brief abstracts of them will be published in a volume to be issued in advance of the meeting. Participation in the congress is open to all interested persons, and detailed information on fees, program, excursions, and so forth can be obtained from K. Headlam Morley, honorary secretary, at 28, Victoria Street, London, S. W. 1.

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A valuable collection of hydrological data on the Rio Grande and its tributaries is presented in *Water Bulletin No. 5* of the International Boundary Commission, United States and Mexico, El Paso, Tex. Stream-flow records of 41 stations for the year 1935, and hitherto unpublished records of 11 stations for the period 1924–1935 are included. Much of this information is also presented graphically by means of hydrographs, mass curves, and duration curves. Detailed chemical and bacteriological analyses of the water, and a map showing lines of equal average annual evaporation from free water surfaces, are other important features.

* * * *

A series of five booklets on "Sportsmanlike Driving" is being prepared by the American Automobile Association. The first two, entitled "The Driver" and "Driver and Pedestrian Responsibilities" have recently come from the press. The former discusses the physical and psychological attributes that determine a person's driving ability, such as eyesight, general health, and reaction time, and presents an interesting "personal rating project" that should help every driver to find his weaknesses and increase his skill. The latter takes up such subjects as "obligations of the driver" and "safeguarding the pedestrian." These pamphlets should be of especial value for class use, in high schools and elsewhere. Burton W. Marsh, M. Am. Soc. C.E., and Peter J. Stupka, Assoc. M. Am. Soc. C.E., had an important part in their preparation.

NEWS OF ENGINEERS

Personal Items About Society Members

Dean F. Peterson, Jr., is now junior road engineer for the Shoshone Indian reservation at Fort Washakie, Wyo. Mr. Peterson was formerly a junior engineer, WPA for Utah, at Provo, Utah.

Carl G. W. Swanson was recently appointed a resident engineer inspector for the Resettlement Administration. Previously he was assistant professor of concrete design at Virginia Polytechnic Institute.

S. F. Crecelius, who, as project engineer for the International Boundary Commission, has been making surveys and investigations preliminary to the canalization of the Rio Grande, is now with the U. S. Bureau of Reclamation in charge of construction of Caballo Dam on the Rio Grande.

Bruce Gentry, formerly chief engineer for the W. E. Callahan Construction Company and Gunther and Shirley on the All-American Canal at Yuma, Ariz., is now construction engineer for the Hardwick Company, Inc., at Eagle Pass, Tex.

William M. Spann has resigned as state director of the Public Works Administration in Missouri to devote his time to private engineering practice in Kansas City.

Benjamin F. Williams was recently appointed project engineer in the Texas Public Works Administration and assigned to the Willacy County Water Control and Improvement District No. 1 at Raymondville, Tex. Previously he was engineer inspector for the same organization at Brownsville, Tex.

Thomas E. Willier, special assignment engineer for the Missouri State Highway Commission, has been awarded a Harvard University fellowship for the study of street and highway traffic control and safety. He will be in Cambridge, Mass., for the coming year.

George D. MacNaughton has resigned from the New Jersey State Highway Department to become civil engineer for the Hill Dredging Corporation, of Ventnor, N.J.

Thomas K. A. Hendrick is now with the New York City Board of Water Supply.

Arthur J. Trapp, formerly project analyst for the Resettlement Administration in Washington, D.C., is now regional engineer inspector for Region II of the Resettlement Administration. His present headquarters are in Milwaukee, Wis.

Lawrence H. Hunt, formerly with the Inland Steel Company, of East Chicago, Ind., is now office engineer in the Chicago district office of the Portland Cement Association.

Richard T. Larsen has been transferred from the Denver office of the U. S. Bureau of Reclamation, where he was assistant engineer, to the Salt River Project at Phoenix, Ariz. He is now associate engineer.

Thomas U. Taylor, dean of the college of engineering of the University of Texas, was recently retired with the rank of dean emeritus.

Donald G. Gentry is now employed as an assistant engineering aide in the design offices of the U. S. Engineer Office at Mineral Wells, Tex. Formerly he was junior engineering aide on the U. S. Forest Service's plains shelterbelt project at Wichita Falls, Tex.

Ray A. Campbell has left the Swenson Lumber Company, of Laramie, Wyo., where he was engineer, to enter the employ of the Peter Kewitt Sons Construction Company, in Omaha, Nebr.

Harold S. Carter, previously head of the civil engineering department of South Dakota State College, is now professor of civil engineering at the Utah State Agricultural College, Logan, Utah.

Clarence A. Walkwitz has been transferred from the U. S. War Department at Fort Riley, Kans., where he was superintendent of construction, to the U. S. Veterans Administration at Veterans Facility, St. Cloud, Minn., in a similar capacity.

E. L. Chandler, formerly chief engineer of the Chattanooga Flood Protection District at Chattanooga, Tenn., is now principal civil engineer for the Tennessee Valley Authority, with headquarters at Knoxville, Tenn.

John F. Bruce is now a draftsman in the U. S. Engineer Office at St. Joseph, La. He was previously junior project engineer for the Department of Roads and Irrigation, Lincoln, Nebr.

ANNUAL MEETING of the Society, New York, N.Y., January 20–23, 1937

JOHN W. COMER has become an instructor in civil engineering at the Oklahoma Agricultural and Mechanical College, Stillwater, Okla.

T. G. CROOM recently accepted a position as engineer with the Bureau of Sanitary Engineering of the Indiana State Board of Health. Formerly he was sanitation consultant for the U. S. Public Health Service, in Chicago, Ill. Mr. Croom's new headquarters are in Indianapolis.

R. M. LA FOLLETTE, previously with the Currie Engineering Company, of Webster City, Iowa, has entered the employ of Charles A. Haskins, consulting engineer of Kansas City, Mo.

FRED J. BENSON has left the civil engineering department of the Agricultural and Mechanical College of Texas to become an instructor in testing materials at Purdue University.

ARTHUR H. HERBERGER is now junior sanitary engineer for the Bureau of Marine Fisheries of the New York State Conservation Department, with headquarters at Freeport, L.I. He was formerly an assistant instructor at New York University.

ISAAC S. WALKER, consulting engineer of Philadelphia, Pa., was recently engaged by the National Resources Committee as associate water consultant for District No. 2 for the purpose of making a study of the Delaware River drainage basin with a view to coordination of interests on power, navigation, irrigation, recreation, flood control, and water supply.

HENRY P. EVANS, JR., has resigned from the U. S. Bureau of Reclamation in Denver, where he was in the outlet-works design section, to accept an appointment as an associate in the civil engineering department at the University of Illinois.

CARL F. MEYER, assistant professor of civil engineering at Worcester Polytechnic Institute, is serving as exchange professor of engineering at the University of Hawaii in Honolulu during the present school year.

PAUL N. IVANCICH was recently placed in command of CCC Camp S.P.-41-T at Sweetwater, Tex.

HARRY MCGRAW has resigned as division engineer of the West Virginia State Road Commission in order to become a partner in the contracting firm of W. H. Armstrong, of Washington, D.C.

S. S. STEINBERG, head of the department and professor of civil engineering at the University of Maryland, has been appointed acting dean of the college of engineering.

GLEN E. EDGERTON, lieutenant-colonel, Corps of Engineers, U. S. Army, has been appointed engineer of maintenance for the Panama Canal Zone.

E. H. DUNMIRE has left the consulting engineering firm of Black and Veatch, of Kansas City, Mo., where he was employed for the past 16 years, to become engineer-manager of the North Loup Public Power and Irrigation District at Ord, Nebr.

HARRY R. HALL, chief engineer of the Washington Suburban Sanitary Commission, has been appointed lecturer on municipal sanitation at the University of Maryland.

EDWIN C. FRANZEN, assistant engineer, U. S. Engineer Corps, was recently transferred from Rock Island, Ill., to Washington, D.C., where he is in the office of the chief of engineers.

MORTIMER E. COOLEY, dean emeritus of the colleges of engineering and architecture at the University of Michigan, has been honored through the new bridge across the Manistee River near Wellston, Mich., which has been given his name. The bridge was awarded first prize in its class for 1935 by a jury selected by the American Institute of Steel Construction.

MORTIMER E. COOLEY BRIDGE

GERALD W. KNIGHT, is now executive secretary of the Interstate Sanitation Commission, New York City.

E. W. BACKES has resigned as chief engineer and western representative of Standard Equipments, Inc., Chicago, Ill., to become sales engineer for the Rail Joint Company, of the same city.

MALCOLM D. LINDEMAN is now superintendent of the Sill Construction Company, of Chicago, Ill. Formerly he was with the Resettlement Administration in Lincoln, Nebr.

ROBERT LINTON, consulting engineer of Los Angeles, Calif., was recently appointed a member of the California State Mining Board, an advisory body charged with determining the general policies of the California Division of Mines.

JOHN L. NAGLE, formerly assistant chief of the Eastern Division, Branch of Engineering, National Park Service, in Washington, D.C., was recently transferred to St. Louis, Mo., where he is superintendent of the Jefferson National Expansion Memorial of this Service.

MERLE C. HOLLINGSWORTH was recently appointed assistant resident engineer inspector, Public Works Administration, San Francisco, on the construction of a water-filtration plant for the city of Santa Barbara, Calif. Previously he was an engineering draftsman in the U. S. Bureau of Public Roads in San Francisco.

JESSE E. BUCHANAN is now research engineer for the Asphalt Institute, San Francisco, Calif. Formerly he was testing engineer in the Idaho Bureau of Highways.

WALTER P. BLOECHER, previously an engineer with the Stone and Webster Engineering Corporation, at Haverford, Pa., is now with the Philadelphia and Reading Coal and Iron Company.

ANTHONY D. ALDERSON has resigned as engineering field aide in the U. S. Engineer Department at Iowa City, Iowa, to enter the structural department of the Minneapolis, St. Paul, and Sault Sainte Marie Railway Company. His headquarters are in Minneapolis, Minn.

S. J. CHAMBERLIN, formerly instructor of engineering drawing in Burlington (Iowa) Junior College, is now instructor of theoretical and applied mechanics in Iowa State College.

JOSEPH FERTIK is now assistant engineer for the New York City Board of Water Supply. He was previously chief engineer for the Atwell-Montee Caisson Corporation, of the same city.

JOHNSON L. FORBIS, who was employed as an instrumentman in the Oklahoma State Highway Department, has been made director of operations, Seventh WPA District of Oklahoma, with headquarters in Chickasha, Okla.

VICTOR K. SCHEGOLKOV is now connected with the American Smelting and Refining Company in Tacoma, Wash. Formerly he was structural draftsman for the Isaacson Iron Works, of Seattle.

S. E. KAPPE has resigned his position with the U. S. Engineer Office in Philadelphia, Pa., where he was engineer in charge of a pollution study of the Delaware River and its main tributaries, to become sanitary engineer with the Chicago Pump Company. After several months in Chicago Mr. Kappe expects to open the pump company's office in Philadelphia.

HENRY O. FRAAD has become president of the Allied Pneumatic Services, Inc., with headquarters in New York City. Previously he was chief engineer of this company.

VERNON P. JENSEN is now in the materials testing laboratory of the University of Illinois, where he is special research assistant professor of theoretical and applied mechanics. He was previously at Iowa State College.

DECEASED

ALBERT READ BAKER (Assoc. M. '13) for the past seven years with the Metropolitan Water District of Southern California, died in San Marino, Calif., on Sep-

tember 7, 1936. He was 54. Mr. Baker, who was born at Norwalk, Ohio, was educated at the University of California. From 1905 to 1909 he was on the Stanislaus River hydroelectric development, and from 1912 to 1919 was chief engineer on construction for the Marin (Calif.) Municipal Water District. Later he was associated with the Hetch Hetchy water project of San Francisco, and in 1927 he entered the contracting field. In 1929 he joined the water district staff.

Robert Carr Churchill (M. '27) general contractor and president of the R. C. Churchill Company, of Roanoke, Va., died in Staunton, Va., on September 9, 1936. Mr. Churchill, who was 45, was educated at the Sheffield school of engineering, Yale University. Following his graduation in 1912, he was employed by Flickwir and Bush, contractors, and later by the Westinghouse Electric Company and by Church, Kerr and Company, of New York. During the war he served as a lieutenant in France with the Twelfth Engineers, attached to the British army. Returning to Roanoke at the close of the war, he was engaged on construction work for the Norfolk and Western Railway Company and the Virginian Railway before establishing his own firm.

James Andrew Fairleigh (M. '91) secretary and treasurer of the Cushman-Fairleigh Engineering Company, of Chattanooga, Tenn., died at his home in that city on September 18, 1936. Mr. Fairleigh was born in Brandenburg, Ky., and educated at Rensselaer Polytechnic Institute. In 1888, after early experience in railroad engineering work, he became city engineer of Chattanooga, where he was in charge of sewer installations and other municipal projects. After three years in this position, he was engaged as resident engineer on the construction of the Walnut Street Bridge across the Tennessee River at Chattanooga. In 1892 he established the general engineering practice in which he continued for almost 50 years.

William Hauck (Assoc. M. '01) deputy chief engineer of the New York City Department of Water Supply, Gas, and Electricity, died in New York on September 20, 1936. Mr. Hauck, who was 62, was born in Watertown, Mass. Following his graduation from the Lawrence Scientific School in 1896, he spent several years in engineering work in Boston and its vicinity. He later served as assistant engineer for the Interborough Rapid Transit Commission in New York City. He was borough engineer of the Bronx division, Department of Water Supply, Gas, and Electricity, for some years before becoming deputy chief a few months ago.

Clarence Scott Howell (Assoc. M. '17) consulting engineer of New York City, died at his home in Cos Cob, Conn., on September 23, 1936, at the age of 61. Mr. Howell, who was born in New York City, was an authority on foundations and the inventor of a new method of pile driving. From 1911 to 1914 he was a member of the engineering and architectural firm of Howell and Howell, of New York, and from 1914 to 1916 he was chief engineer for the Giant Concrete Pile Company of that city. During the war he served with the 551st Engineers, and after the armistice again became connected with the Giant Concrete Pile Company. Later he established a consulting practice.

John Franklin Jackson (Assoc. M. '94) consulting engineer of Milwaukee, Wis., died in that city on August 22, 1936, at the age of 71. Mr. Jackson was born in Hicksville, Ohio, and graduated from the Ada (Ohio) Normal University in 1886. For a number of years he was connected with the Wisconsin Bridge and Iron Company. Entering as contracting engineer, he rose to be vice-president. From 1921 to 1933 he was president of the Kidwell Boiler and Engineering Company, of Milwaukee, establishing his consulting practice in the latter year. Mr. Jackson supervised construction of the vehicular bridge over the Mississippi River at Burlington, Iowa; a bridge across the Ohio at Ironton, Ohio; and the ore deck at Marquette, Mich.

The Society welcomes additional biographical material to supplement these brief notes and to be available for use in the official memoirs for "Transactions."

Charles Seymour Kimball (M. '12) of Washington, D.C., died on August 29, 1936, at the age of 57. Mr. Kimball was born in Dubuque, Iowa. He served in the drafting department of the Metropolitan Street Railway Company of New York from 1894 to 1900. Later he was with the Rapid Transit Subway Construction Company and in the bridge department of Westinghouse, Church, Kerr and Company, of New York. Beginning in 1904, he served as engineer of way and structures for the Washington Electric Railway Company for over twenty years. Later he was civil engineer for the Portland Cement Association in Washington, D.C., and from 1932 until 1934 was in the engineering department of the Capital Traction Company of that city.

Merritt Lemuel Pike (Jun. '28) project superintendent, ECW, U. S. Department of Agriculture, at CCC Camp, S-59 New Lisbon, N.J., died on April 8, 1936. Mr. Pike was born in Westville, N.J., on February 2, 1907, and graduated from Drexel Institute in 1928. From 1927 to 1929 he was junior engineer for the New Jersey State Highway Department and later was resident engineer for the Standard Oil Company of Pennsylvania at Philadelphia. In 1933 he became a foreman at the CCC Camp at New Lisbon, where he later served as project superintendent.

John Melvin Reardon (Assoc. M. '28) superintendent of construction and repair for the St. Paul (Minn.) Department of Public Works, died on September 29, 1936. Mr. Reardon, who was 36, was born in St. Paul and educated at the University of Minnesota. After his graduation in 1922, he became assistant superintendent of construction for the Butler Brothers Building Company on highway paving operations. In December 1923 he entered the employ of the city of St. Paul as assistant engineer in direct charge of sewer construction. In 1932 he became superintendent of construction and repair for the city.

William Fullerton Reeves (M. '12) assistant engineer for the Interborough Rapid Transit Company, New York City, died there on September 18, 1936, at the age of 77. Mr. Reeves was born in New York and educated at New York University. Upon his graduation in 1880, he entered the employ of the Manhattan Railway Company as a civil engineer, and continued in this post when the company was taken over by the Interborough Rapid Transit Company in 1903. Later he became assistant engineer. Mr. Reeves specialized in the legal business of the engineering department and was an authority on contracts and easements. He was the author of a recent book on early elevated railways in New York City.

James Herbert Richardson (M. '30) died in New York City on September 1, 1936. He was born in Lawrence, Mass., on October 3, 1876, and was educated at Massachusetts Institute of Technology. From 1902 to 1909 he was employed by the American Bridge Company, and from 1910 to 1916 was with the Boston and Albany Railroad Company. He designed many steel and concrete arches and special bridge structures for the latter. During the war he served overseas as a captain in the Engineer Corps of the army. From 1924 to 1927 he was assistant engineer on the construction of the Holland Tunnel. In the latter year he entered the employ of the New York City Board of Water Supply, where he remained until 1934.

John Cassan Wait (M. '92) civil engineer and attorney of New York City, died on October 4, 1936, at Chenango Lake, N.Y., where his summer home was located. He was 76. A native of Norwich, N.Y., Mr. Wait received a civil engineering degree from Cornell University in 1882 and a degree in law from Harvard Law School in 1891. From 1887 to 1894 he was a member of the Harvard faculty. In 1896 and 1897 he was engineer in charge of the $9,000,000 improvements being made on the New York state canals. From 1899 on he was engaged in the practice of law in New York City. Mr. Wait was the author of several books. Of these the best known is probably his *Engineering and Architectural Jurisprudence*.

Bruce Clinton Yates (M. '23), for the past 18 years general manager of the Homestake Mining Company, of Lead, S. Dak., died there on August 10, 1936, at the age of 67. Mr. Yates was born near Grafton, W.Va., and graduated from the

University of Nebraska in 1892. After several years in the maintenance-of-way department of the Chicago, Burlington, and Quincy Railroad, he established a general surveying and mining engineering practice. His firm was dissolved in 1897, when he became mine surveyor for the Homestake Mining Company. First he was promoted to the position of chief engineer and later to that of assistant general manager. In 1918 he became general manager.

EDITOR'S NOTE: Through an unfortunate error, the name of Frederick Calvin Davis, M. Am. Soc. C.E., of San Francisco, Calif., was included among the deceased in the March issue of CIVIL ENGINEERING. This error occurred through confusing his name with that of Frederick Davis, Assoc. M. Am. Soc. C.E., of Santa Cruz, Calif., whose death occurred on January 25, 1936. Mr. Frederick C. Davis is construction engineer for Gladding McBean and Company of San Francisco.

Changes in Membership Grades

Additions, Transfers, Reinstatements, and Resignations

From September 10 to October 9, 1936, Inclusive

ADDITIONS TO MEMBERSHIP

ADAMS, ROBERT FRANCIS (Jun. '36), Care, Dept. of Applied Mechanics, Kansas State Coll., Manhattan, Kans.

ALBERGA, ALVYN CLYDE (Jun. '36), Engr. Aide, TVA, Dept. of Electricity, Wilson Dam, Ala.

BEAN, SHERMAN HUNN (Jun. '36), 2357 North West Irving St., Portland, Ore.

BEAR, HERBERT STANLEY (M. '36), Lt.-Commander, C.E.C., U.S.N., Public Works Officer, Great Lakes, Ill.

BERG, LOUIS LEIGHTY (Jun. '36), Development and Service Engr., Elec. Tamper & Equipment Co. (Res., 409 North Rath Ave.), Ludington, Mich.

BESOZZI, LEO (Assoc. M. '36), Superv. Engr., Dept. of Water Works (Res., 52 Ruth St.), Hammond, Ind.

BROWN, STANLEY MONTGOMERY (Assoc. M. '36), State Maintenance Engr., State Highway Dept., 710 Twelfth St., Bismarck, N.Dak.

BUCK, JOHN ELMER (Jun. '36), 1111 Highland Ave., Knoxville, Tenn.

BUSSEY, ARTHUR STANLEY (Jun. '36), 513 Thirty-Fifth St., West Palm Beach, Fla.

BYRNS, FORREST EUGENE (Assoc. M. '36), Associate Engr., U. S. Engr. Office, War Dept., 39 Whitehall St., New York (Res., 68 Cambridge Ave., Garden City), N.Y.

CAESAR, GEORGE PHILIP ENGLER, JR. (Jun. '36), Hamilton Hall, B 22, Soldiers Field, Boston, Mass.

CAPP, CRAIG THOMAS (Jun. '36), Draftsman, Bridge Design Dept., State Highway Comm. (Res., 1239 Orchard Drive), Ames, Iowa.

CIOCHETTO, FRANK CHARLES (Jun. '36), 430 West 12th St., Pueblo, Colo.

COCHRAN, ALBERT LUDWELL (Jun. '36), Junior Engr., U. S. Engr. Office, 608 Postal Telegraph Bldg., Kansas City, Mo.

DEMENT, JAMES WASHINGTON, JR. (Jun. '36), U. S. Engr. Office, Bock-Fischel Bldg., Vicksburg, Miss.

DIPPOLD, DANIEL STUBBS (Jun. '36), 1004 Grand Ave., Edwardsville, Ill.

DORNER, WILLIAM JOHN (Jun. '36), 1336 South East 48th Ave., Portland, Ore.

DREISSEN, ROBERT EDWARD ERIC (Jun. '36), Central Y. M. C. A., St. Paul, Minn.

DUBIN, MILTON (Jun. '36), Cartographer, Met. Model Project (Res., 2505 Lorillard Pl.), New York, N.Y.

DUNNING, WILLIAM ALFRED (Assoc. M. '36), with Los Angeles County Flood Control Dist. (Res., 1544 Cerro Gordo St.), Los Angeles, Calif.

DUNTON, ALLEN HENRY (Jun. '36), 306 West 3d St., Muscatine, Iowa.

DUVALL, PHILIP KIRK (Assoc. M. '36), Gen. Contr. (Duvall & McKinney), Logan, Iowa.

DYE, FORREST LESLIE, JR., (Assoc. M. '36), With U. S. Engr. Office, Box 97, Memphis, Tenn.

FINNILA, ALFRED AUGUST (Jun. '36), 2284 Market St., San Francisco, Calif.

FRESEN, MARTIN HENRY (Assoc. M. '36), Associate Engr., U. S. Bureau of Reclamation (Res., 1161 South High St.), Denver, Colo.

GAYLORD, EDWIN HENRY, JR., (Assoc. M. '36), Asst. Prof., Civ. Eng., Ohio Univ., Box 181, Athens, Ohio.

GELDERMAN, JACOB (Jun. '36), 616 West Diamond St., Onawa, Iowa.

GERHART, JOHN WALLACE (Jun. '36), 2360 Linden Ave., Long Beach, Calif.

GOSLINE, GEORGE WILLIAMS (Assoc. M. '36), Dist. Engr., U. S. Dept. of Agriculture, SCS, 213 Main St., Watsonville, Calif.

GREEN, ROBERT SMITH (Jun. '36), 432 Monroe St., Gary, Ind.

GREENBERG, JACK (Assoc. M. '36), Asst. Structural Engr., City of Detroit (Res., 1927 Pingree Ave., Apartment 316), Detroit, Mich.

GREGORY, GEORGE ARTHUR (Assoc. M. '36), Res. Engr. Insp., PWA, Tacoma (Res., 1217 Jefferson St., Olympia), Wash.

HAND, ROBERT DAVID (Jun. '36), With M. of W. Dept., C. & O. Ry., Care, Car EC-2, C. & O. Ry., Richmond, Va. (Res., 412 Courtland Ave., Park Ridge, Ill.).

TOTAL MEMBERSHIP AS OF OCTOBER 9, 1936	
Members	5,639
Associate Members	5,955
Corporate Members	11,594
Honorary Members	19
Juniors	3,102
Affiliates	89
Fellows	1
Total	14,805

HATCH, GEORGE EDWIN (Jun. '36), Wessington Springs, S. Dak.

HOLLOWAY, JOHN CARRINGTON, JR. (Jun. '36), Y. M. C. A., Aberdeen, S.Dak.

HORNE, CLEVELAND REID, JR. (Jun. '36), 211 University Terrace, Gainesvil e, Fla.

HURLOW, HUGH, JR., (Assoc. M. '36), Dist. Mgr., Am. Cable Co. and Hazard Wire Rope Co. (Res., 515 North Cushman St.), Tacoma, Wash.

Isé, HENRY (Assoc. M. '36), Asst. Engr., Scituate Reservoir Div., Dept. of Public Works, City Hall, Providence, R.I.

ISTO, REYNOLD EDWARD (Jun. '36), Newell, S.Dak.

JACKSON, DUGALD CALEB, JR. (M. '36), Director, Lewis Inst., 1951 West Madison St., Chicago, Ill.

JOHNSON, MAYNARD DOUGLAS (Jun. '36), 1311 South Main St., South Bend, Ind.

JONES, ALBERT BARNETT (M. '36), Maj., Corps of Engrs., U.S.A.; Dist. Engr., Duluth Dist., U. S. Engr. Office, Duluth, Minn.

JONES, SAMUEL LEARY (Jun. '36), 318 Fourteenth St., University, Va.

KAHL, WILLIAM GROVER (Jun. '36), 1407 Valentine Rd., Kansas City, Mo.

KITTRELL, CLARK (M. '36), Care, U. S. Engr. Office, Fort Peck, Mont.

KUHL, LEWIS CHARLES, JR. (Assoc. M. '36), Structural Designer and Checker, Turner Constr. Co., Eng. Dept., 420 Lexington Ave., New York, N.Y. (Res., 1152 Coolidge Rd., Elizabeth, N.J.).

LAMSON, WILLIAM DEANE (Jun. '36), 561 East 9th St., Brooklyn, N.Y.

LAVALLEY, EDWARD CLOVIS (Assoc. M. '36), Instr., Eng. Drawing, Coll. of Eng., New York Univ., New York (Res., 227 Eastchester Rd., New Rochelle), N.Y.

LEMONDS, DONALD ARTHUR (Jun. '36), 808 East 64th St., Seattle, Wash.

LEONARD, GEORGE KINNEY (M. '36), Constr. Engr., TVA, Guntersville Dam, Ala.

LEY, ROBERT TAIT (Jun. '36), Engr., Fred T. Ley & Cia., S.A., Apartado Postal 1219, Bogota, Colombia.

LIEBERMAN, HARRY ALVIN (Jun. '36), 3424 West North Ave., Chicago, Ill.

LIENHARD, FREDERICK (M. '36), Engr., Leon S. Moisseiff, 99 Wall St., New York, N.Y.

LINGO, ROBERT MYRON (Jun. '36), 7-D Godfrey Court, Fort Riley, Kans.

Linsky, David Joseph (Jun. '36), 1135 Fifty-fourth St., Brooklyn, N.Y.

Lunt, Randle Gibson (Assoc. M. '36), Senior Draftsman with Los Angeles County Surv. (Res., 231 North Ave. 60), Los Angeles, Calif.

MacDonald, Harold Joseph (Assoc. M. '36), Field Supervisor of Constr., Colonial Beacon Oil Co., Boston (Res., 48 Banks St., Cambridge), Mass.

McCann, Eugene Harrison, Jr., (Jun. '36), Junior Engr., Humble Oil & Refining Co. (Res., 1648 Bonnie Brae), Houston, Tex.

McKee, Jack Edward (Jun. '36), With TVA (Res., 620 Seventeenth St.), Knoxville, Tenn.

Magnuson, Nels Conrad (Assoc. M. '36), Hydrographer and Res. Engr., U. S. Geological Survey (Res., 504 East Mary St.), Austin, Tex.

Malek, Joseph Stanley (Jun. '36), 77 Main St., Manchester, Conn.

Marrone, Adolph Alfred (Jun. '36), Rodman and Chainman, Madigan-Hyland, 521 Fifth Ave., New York (Res., 133 North 5th Ave., Mount Vernon), N.Y.

Matteson, Eldon Franklin (Jun. '36), Unadilla Forks, N.Y.

Mautz, Ferdinand Francis (Jun. '36), 1133 Hopkins St., Berkeley, Calif.

Meyer, Richard Davis (Jun. '36), Lieut., Corps of Engrs., U. S. A., Fort Belvoir, Va.

Mickey, James Daniel (Jun. '36), Office Engr., Central Nebraska Public Power and Irrig. Dist., Tri-County Project, Hastings, Nebr.

Morrison, George Ian (Jun. '36), East 950 Indiana St., Spokane, Wash.

Nash, George Arthur (Jun. '36), 1129 Oak St., Eugene, Ore.

Nelsen, LaVern James (Jun. '36), Designer, The Central Nebraska Public Power and Irrig. Dist. (Res., 838 North Hewitt), Hastings, Nebr.

Nuzum, Charles Richard (Jun. '36), Junior Engr., State Road Comm., Keyser, W.Va.

O'Laughlin, James Francis (Jun. '36), 317 Seventh St., South, Moorhead, Minn.

Orland, Herbert Paul (Jun. '36), With 7th Field Artillery, Fort Ethan Allen, Vt.

Packard, Frank (Assoc. M. '36), Junior Topographical Engr., Conservation Branch, U. S. Geological Survey, Box 1341, Sacramento Calif.

Palmer, Vincent Allen (Jun. '36), Route 2, Box 568, Turlock, Calif.

Pendleton, James Benjamin (Assoc. M. '36), Structural Designer, State Highway Comm., Bridge Design Dept., Masonic Temple (Res., 1421 Western Ave.), Topeka, Kans.

Pendleton, William Lamar (Assoc. M. '36), Chf. Draftsman and Asst. Engr. of Plans, State Highway Dept., Phoenix, Ariz.

Petersen, Harry George (Jun. '36), Concrete Technologist, Golden Gate Atlas Materials Co., San Francisco (Res., 1841 Bancroft St., San Leandro), Calif.

Pfeifer, Frederick Joseph (Assoc. M. '36), Insp. in Chg., State Road Comm., Box 463, Keyser, W.Va.

Picchi, Ferrer (Jun. '36), Asst. to Gen. Field Supt., WPA, New York (Res., 362 Marbledale Rd., Tuckahoe), N.Y.

Pickering, Okie Lee (Assoc. M. '36), Res. Engr. Insp., PWA, Box 401, Bristol, Tenn.

Praught, Clarence Harold (Jun. '36), Junior Engr., U. S. Indian Forestry Service, Red Lake, Minn.

Riddel, John Ormond (M. '36), Res. Engr., Trinidad Central Water Supply Scheme, Trinidad Govt., and Howard Humphreys & Sons, St. Joseph, Trinidad.

Robbins, Howard Edwards (Assoc. M. '36), Associate Engr., U. S. Bureau of Reclamation, Phoenix, Ariz.

Robinson, Camm Paul (Assoc. M. '36), Eng. Asst., Rand Water Board, 74, Commissioner St., Johannesburg, Union of South Africa.

Robinson, Meade Morrison (Jun. '36), 602 South East 1st St., Evansville, Ind.

Russell, John Crittenden (Assoc. M. '36), With Suburban RA; 3305 West Ave., Newport News, Va.

Schlesinger-Carrera, Luis Antonio Miguel (M. '36), Cons. Engr. and Contr., 10a Calle Oriente, No. 11B, Guatemala, Guatemala.

Schulze, Axel (Assoc. M. '36), Pres. and Chf. Engr., Gilmour Steel Products Co., Inc. (Res., 5413 Ridge Ave.), Philadelphia, Pa.

Sheinwald, Benjamin Schellenberg (Jun. '36), 74 Browne St., Brookline, Mass.

Shepard, Charles Harold (Jun. '36), Laboratory Technician, Soil Section, State Highway Testing Laboratory (Res., 65 Thirteenth Ave.), Columbus, Ohio.

Simpson, John Temple (Jun. '36), Junior Engr., Bureau of Reclamation (Res., 1065 Josephine St.), Denver, Colo.

Smith, Joseph William (Jun. '36), Humble Dormitory, Baytown, Tex.

Smith, Thomas Alexander (Jun. '36), Office Engr., State Highway Dept., Div. 5, Fort Davis, Tex.

Tatham, Norman John (Jun. '36), Chairman, Southern California Gas Co.; 203 West Magnolia Ave., Glendale, Calif.

Taylor, Guy Harvey (Jun. '36), 601 North East Irving St., Apartment 204, Portland, Ore.

Taylor, James Donald (Jun. '36), 82 North Harlem, Riverside, Ill.

Thompson, Miles Howlett (Jun. '36), Insp., Hydr. Design, U. S. Engr. Office (Res., 735 Hartford Ave.), Los Angeles, Calif.

Tomlinson, Frederick Bryon (Jun. '36), 63 Hickory St., Bridgeport, Conn.

Utterback, Thomas Eugene (Jun. '36), Asst. Engr. Aide and Research Asst., U. S. SCS, Box 1151, Gallup, N.Mex.

Warren, Frank Kaile, Jr. (Jun. '36), With F. & M. Schaefer Brewing Co., Brooklyn (Res. 103-06 Farmers Ave., Hollis), N.Y.

Waterbury, Lawrence Stuart (Assoc. M. '36), Civ. Engr., 22 East 38th St., New York, N.Y.

Watts, William Ray (Jun. '36), Instrumentman, State Highway Dept., Box 626, Post (Res., 923 Lane Ave., Abilene), Tex.

Werner, Max Alfred, Jr. (Jun. '36), 3030 Western Ave., Peoria, Ill.

West, George Goodson (Assoc. M. '36), Chf., Hydrology Section, U. S. Engrs., 2d Portland Dist. (Res., 1918 South East 28th Ave.), Portland, Ore.

Westman, John Franklyn, Jr. (Jun. '36), 343 East 139th St., New York, N.Y.

White, Joseph Henry (M. '36), With Board of County Commrs., Allegheny County, Pittsburgh, Pa.

Wilson, Harold Walter (Jun. '36), Box 291, Ladoga, Ind.

Youngquist, Ruben Clifford (Assoc. M. '36), Draftsman, Dept. of Water and Power, City of Los Angeles (Res., 5464 West Boulevard), Los Angeles, Calif.

Membership Transfers

Belaeff, Nicholas Platon (Jun. '33; Assoc. M. '36), Field Engr., Madigan & Hyland, 521 Fifth Ave. (Res., 25 Hillside Ave., Apartment 2 K), New York, N.Y.

Christiansen, Jerald Emmett (Jun. '28; Assoc. M. '36), Junior Irrig. Engr., Experiment Station, Coll. of Agriculture, Univ. of California, College Park, Davis, Calif.

Cohen, Paul Arthur (Jun. '27; Assoc. M. '36), Asst. Engr., Bridge Div., Bureau of Highways (Res., 2445 Callow Ave.), Baltimore, Md.

Crocker, Foster Baldwin (Jun. '11; Assoc. M. '13; M. '36), Associate Civ. Engr., State Dept. of Public Works, Div. of Eng., Syracuse, N.Y.

Davis, Philip Kees (Assoc. M. '30; M. '36), Constr. Engr., Joint State Highway Dist. 13 (Res., 5810 Keith Ave.), Oakland, Calif.

Erickson, Archie Milton (Jun. '27; Assoc. M. '36), Cons. Engr.; Faculty Member, School of Architecture, New York University, 1071 Sixth Ave., New York, N.Y.

Frost, Maurice Bayard (Jun. '26; Assoc. M. '36), Engr., New Jersey Water Co., 610 Station Ave. (Res., 219 Eighth Ave.), Haddon Heights, N.J.

Gridley, Horace Velsey (Jun. '24; Assoc. M. '36), Sales Engr., Garlinghouse Bros., 2416 East 16th St., Los Angeles (Res., 256 South Lake Ave., Pasadena), Calif.

Guinn, Rembert Shields (Jun. '29; Assoc. M. '36), Asst. Engr., Bridge Div., State Highway Dept. (Res., 602 West 16th St.), Austin, Tex.

Irvin, Richard (Jun. '10; Assoc. M. '15; M. '36), Archt. and Engr., 101 Vandergrift Bldg., Pittsburgh, Pa.

McKeon, Francis Daniel (Jun. '26; Assoc. M. '36), Asst. Engr., State Highway Dept. (Res., 210 Wellesley Rd.), Syracuse, N.Y.

Osborn, Lewis Knowles (Jun. '29; Assoc. M. '36), Structural Engr., T. C. Kistner, 814 Architects Bldg., Los Angeles (Res., 324 Eliot Court, Long Beach), Calif.

Packman, Ian Buchanan (Jun. '26; Assoc. M. '36), Engr., Pioneer Ice Cream Brands, Inc., 205 East 24th St., New York (Res., 524 South 8th Ave., Mount Vernon), N.Y.

Parsons, Gerald Ernest (Jun. '27; Assoc. M. '36), 5504 Wayne Ave., Baltimore, Md.

Spurney, Felix Emanuel (Jun. '23; Assoc. M. '35), Asst. Supt., Turner Constr. Co., 420 Lexington Ave., New York, N.Y. (Res., 10 Calvert Pl., Kensington, Md.).

Vicente, Elisio Ferreira (Jun. '31; Assoc. M. '36), Structural Engr., James E. Geissberger, 103 Park Ave., New York (Res., 9114 Park Lane South, Woodhaven), N.Y.

Wark, James Evert (Jun. '25; Assoc. M. '36), Engr., Ayres, Lewis, Norris & May (Res., 1014 Rose Ave.), Ann Arbor, Mich.

Reinstatements

Barrows Daniel Joseph, Jun., reinstated Sept. 21, 1936.

Barth, George Russell, Assoc. M., reinstated Aug. 17, 1936.

Blinn, Ray Sharp, M., reinstated Aug. 17, 1936.

Chapin, Richard Norman, Assoc. M., reinstated Aug. 17, 1936.

Clark, Roy Ross, M., reinstated Sept. 14, 1936.

Durrant, Theodore Vincent Scott, Assoc. M., reinstated Aug. 17, 1936.

Ellis, Herbert Cram, Assoc. M., reinstated Sept. 16, 1936.

Hammond, Newton LeRoy, M., reinstated Sept. 11, 1936.

PELLER, JOSEPH PAUL, Assoc. M., reinstated Sept. 14, 1936.

TOVELL, CLARENCE EUGENE, Assoc. M., reinstated Sept. 14, 1936.

WILCOX, HALSTED NEWELL, Assoc. M., reinstated Aug. 17, 1936.

RESIGNATIONS

BUMSTED, EUGENE BRADFORD, M., resigned Sept. 23, 1936.

JONES, RALPH KELLY, Jun., resigned Sept. 17, 1936.

KELCH, NORMAN WALLACE, Assoc. M., resigned Sept. 28, 1936.

RAGAINI, FRANK, Jun., resigned Sept. 10, 1936.

STURMER, DALE EMANUEL, Jun., resigned Sept. 15, 1936.

Applications for Admission or Transfer

Condensed Records to Facilitate Comment of Members to Board of Direction

November 1, 1936 NUMBER 11

The Constitution provides that the Board of Direction shall elect or reject all applicants for admission or for transfer. In order to determine justly the eligibility of each candidate, the Board must depend largely upon the membership for information.

Every member is urged, therefore, to scan carefully the list of candidates published each month in CIVIL ENGINEERING *and to furnish the Board with data which may aid in determining the eligibility of any applicant.*

It is especially urged that a definite recommendation as to the proper grading be given in each case, inasmuch as the grading must be based upon the opinions of those who know the applicant personally as well as upon the nature and extent of his professional experience. Any facts derogatory to the personal character or professional reputation of an applicant should be promptly communicated to the Board.

Communications relating to applicants are considered strictly confidential.

The Board of Direction will not consider the applications herein contained from residents of North America until the expiration of 30 days, and from non-residents of North America until the expiration of 90 days from the date of this list.

MINIMUM REQUIREMENTS FOR ADMISSION

GRADE	GENERAL REQUIREMENT	AGE	LENGTH OF ACTIVE PRACTICE	RESPONSIBLE CHARGE OF WORK
Member	Qualified to design as well as to direct important work	35 years	12 years*	5 years of important work
Associate Member	Qualified to direct work	27 years	8 years*	1 year
Junior	Qualified for sub-professional work	20 years†	4 years*	
Affiliate	Qualified by scientific acquirements or practical experience to cooperate with engineers	35 years	12 years*	5 years of important work
Fellow	Contributor to the permanent funds of the Society			

* Graduation from an engineering school of recognized reputation is equivalent to 4 years of active practice.
† Membership ceases at age of 33 unless transferred to higher grade.

The fact that applicants refer to certain members does not necessarily mean that such members endorse.

ADMISSIONS

ATLAS, WILLIAM, New York City. (Age 21.) Refers to W. Allan, R. E. Goodwin, T. H. Prentice, J. C. Rathbun.

BOLLEN, FLOYD LOWELL, North Platte, Nebr. (Age 33.) Asst. to Project Engr., PWA, Platte Valley Public Power and Irrigation Project. Refers to J. A. Bruce, K. F. Burnett, R. E. Edgecomb, H. D. Jolley, H. J. Kesner.

BRANDT, HARVEY THEODORE, Los Angeles, Calif. (Age 23.) With Dept. of Bldgs., Los Angeles County. Refers to R. M. Fox, D. M. Wilson.

BRANDT, JOHN NICHOLAS, Kansas City, Mo. (Age 32.) Jun. Engr., U. S. Engr. Office, Kansas City, Mo. Refers to J. P. Edstrand, G. A. Hathaway, D. H. McCoskey, F. A. Russell, H. K. Shane, A. R. Your[illegible].

CASAGRANDE, ARTHUR, Cam[illegible]dge, Mass. (Age 34.) Asst. Prof. of Civ. Eng., Graduate School of Eng., Harvard Univ. Refers to G. M. Fair, G. Gilboy, F. A. Marston, H. A. Mohr, C. S. Proctor, F. E. Schmitt, C. Terzaghi.

CONNER, STANLEY JACK, JR., Philadelphia, Pa. (Age 22.) Refers to W. S. Lohr, E. H. Rockwell.

COVELL, WILLIAM EDWARD RAAB, Oakmont, Pa. (Age 43.) Dist. Engr., U. S. Engrs., Pittsburgh (Pa.) Office. Refers to G. E. Barnes, S. C. Godfrey, J. P. Growdon, H. A. Hickman, B. B. Somervell, H. A. Thomas, M. C. Tyler.

DALTO, PETER ALBERT, St. Albans, N.Y. (Age 36.) Chf. of Party, Dept. of Parks, New York City. Refers to A. M. Anderson, A. J. Barzaghi, E. Praeger, N. K. Torsky, J. Wilmot.

DANIELLS, PERCY HIRAM, Jefferson City, Mo. (Age 47.) Engr. of Surveys and Plans at State Headquarters, Missouri State Highway Dept. Refers to B. L. Brown, A. P. Greensfelder, W. A. Heimbuecher, F. G. Jonah, J. C. Travilla.

EWALD, ARDEN ANTON, Knoxville, Tenn. (Age 38.) Asst. Structural Engr., Dams Div., TVA. Refers to S. B. Barnes, A. A. Burger, D. E. Donley, J. M. Heffelfinger, Jr., W. A. Knapp, R. M. Riegel, L. B. Westfall.

FAY, EDWARD CHARLES, JR., Drexell Hill, Pa. (Age 21.) Refers to W. H. Barton, C. A. Howland, S. B. Lilly, F. L. Martin, C. E. Myers, C. S. Shaughnessy, J. G. Shryock.

FREEBOROUGH, BENJAMIN BONNETT, Austin, Tex. (Age 35.) Inventory Mgr., Statewide Highway Planning Survey, Texas State Highway Dept. Refers to W. D. Dockery, G. G. Edwards, M. B. Hodges, H. H. Peel, K. K. Prestridge, H. P. Stockton, Jr.

FUGITT, GEORGE LEMUEL, Jetmore, Kans. (Age 24.) Refers to L. E. Conrad, O. J. Eidmann, F. F. Frazier, L. B. Fugitt, M. W. Furr.

GARRELTS, JEWELL MILAN, Jackson Heights, N.Y. (Age 33.) Associate in Mechanics, Columbia Univ.; Engr. with Waddell & Hardesty, New York City. Refers to J. W. Barker, J. K. Finch, S. Hardesty, O. E. Hovey, W. J. Krefeld, S. J. Ott, J. E. Wadsworth.

GILBERT, JOHN MILES, St. Louis, Mo. (Age 23.) Draftsman with Russell & Axon, Cons. Engrs. Refers to J. C. Pritchard, G. S. Russell, E. O. Sweetser.

GRAY, HAMILTON, Gardiner, Me. (Age 26.) With Moran & Proctor, New York City. Refers to G. M. Fair, A. Haertlein, L. J. Johnson, H. M. Turner.

GRAY, WALTER JOSEPH, Ames, Iowa. (Age 20.) Research Asst., Eng. Experiment Station, Iowa State Coll. Refers to W. Allan, J. C. Rathbun.

GREICUS, SIGMUND EDWARD, Glasgow, Mont. (Age 31.) Inspector, Gen. Constr., U. S. Engrs., Ft. Peck Dam, Mont. Refers to W. S. Henderson, W. A. Knapp, G. E. Lommel, G. W. Miller, R. B. Wiley.

GRIFFITHS, THOMAS WILLIAM, Glendale, Calif. (Age 23.) Surveyman, U. S. Engrs., being Chf. of Constr. Survey Party, Haines and Dunsmuir Canyons. Refers to R. R. Martel, W. W. Michael, F. Thomas.

GROVES, JOHN MEYBIN, Norris, Tenn. (Age 27.) Jun. Hydr. Engr., TVA, Hydraulic Laboratory, Norris, Tenn. Refers to F. J. Evans, A. S. Fry, G. H. Hickox, F. M. McCullough, C. B. Stanton, H. A. Thomas, J. H. Wilkerson.

HAYWARD, HOMER JAMES, Ann Arbor, Mich. (Age 34.) Engr. with Shoecraft, Drury & McNamee. Refers to A. J. Decker, W. R. Drury, W. C. Hoad, R. L. McNamee, R. H. Sherlock, E. C. Shoecraft, G. F. Wyllie.

HELVENSTON, HUMBOLDT REY, Pittsburgh, Pa. (Age 30.) Gen. Field Supt. with Henry Busse, Gen. Contr. Refers to J. B. Bassett, W. N. Dambach, J. H. Dowling, C. G. Dunnells, F. D. McEnteer, G. McFadden, T. D. Mylrea, K. Riddle, W. F. Trimble.

HENDERSON, THOMAS WAYNE, Dixon, Ill. (Age 22.) Jun. Civ. Engr., Super Power Co. of Illinois. Refers to C. A. Ellis, R. B. Wiley.

HORN, SAMUEL JAMES, Metuchen, N.J. (Age 43.) Draftsman, Dept. of Chf. Engr., Pennsylvania R.R., New York City. Refers to H. G. Altvater, E. J. Burke, C. D. Conklin, Jr., W. S. Lohr, T. B. Rights.

Houser, Edward Anderson, Arkansas City, Kans. (Age 24.) Chainman, Atchison, Topeka and Santa Fe R.R. Co. Refers to L. E. Conrad, F. F. Frazier, M. W. Furr.

Hu, Shao-Yuan, Iowa City, Iowa. (Age 23.) Refers to E. W. Lane, F. T. Mavis.

Jensen, Myron Orval, Asheville, North Carolina. (Age 25.) Asst. Eng. Aide and Junior Hydr. Engr., French Broad River Basin, with TVA. Refers to A. S. Fry, B. E. Morriss, J. C. Prior, C. B. Sherman.

Kreipke, Merrill Vincent, Evansville, Ind. (Age 20.) Refers to C. A. Ellis, R. B. Wiley.

Kulas, Frank Edward, Dormont, Pa. (Age 27.) Engr. of Concrete Tests, Jones & Laughlin Steel Corporation, Pittsburgh, Pa. Refers to F. J. Evans, H. A. Thomas.

Luppens, Joseph Charles, Brooklyn, N.Y. (Age 26.) Jun. Engr., U. S. Engr. Office, 1st Dist., New York City. Refers to F. B. Harkness, W. C. McNown, W. B. Moss.

McGowan, John, Denver, Colo. (Age 29.) Office Engr., Moffat Tunnel, with Herbert S. Crocker. Refers to M. S. Bitner, H. S. Crocker, D. D. Gross, L. R. Howson, H. L. Potts, R. J. Tipton.

Maier, Joseph, Astoria, N.Y. (Age 38.) Vice-Pres., Balaban-Gordon Co., Inc., Engrs. and Contrs., New York City. Refers to E. Balaban, J. F. Krakauer, S. Lengyel, J. Loewenstein, A. C. Penman.

Martin, Hunt Vreeland, St. Thomas, Virgin Islands. (Age 30.) Officer in charge of construction, Marine Aviation Facilities; Lieut. (C.E.C.), U. S. Navy. Refers to W. H. Allen, W. M. Angas, R. E. Bakenhus, J. T. Mathews, A. L. Parsons, N. M. Smith.

Matheny, Charles Woodburn, Jr., Sarasota, Fla. (Age 22.) Rodman, Resettlement Administration, Scottsboro, Ala. Refers to W. W. Fineren, P. L. Reed.

More, Lee Dallas, St. Louis, Mo. (Age 31) Instructor, Civ. Eng. Dept., Washington Univ. Refers to A. H. Baker, A. H. Fuller, R. S. Johnston, F. Kerekes, L. O. Stewart.

Nordenson, Tor Julius, Hancock, Mich. (Age 23.) Instrumentman, Michigan State Highway Dept. Refers to L. M. Gram, C. T. Johnston, H. W. King, W. C. Sadler, R. H. Sherlock.

Ortino, John Thomas, Seneca Falls, N.Y. (Age 26.) Jun. Hydr. Engr., Water Resources Branch, U. S. Geological Survey, Albany, N.Y. Refers to H. B. Alvord, C. H. Brown, R. M. Genthon, E. A. Gramstorff, A. W. Harrington, J. F. Pierce.

Porter, Warren Leslie, Davenport, Iowa. (Age 42.) Rate and Appraisal Engr. and Vice-Pres., United Light & Power Eng. & Constr. Co. Refers to T. R. Agg, J. J. McShane, A. Marston, N. T. Veatch, Jr., W. G. Woolfolk.

Quirin, Edward Joseph, Woodside, N.Y. (Age 25.) Structural Engr., Mayers, Murray & Phillips, Archts., New York City. Refers to R. Evers, E. Praeger, E. J. Squire.

Reed, William George, Long Beach, Calif. (Age 51.) Res. Engr., Federal PWA. Refers to O. G. Bowen, P. E. Jeffers, D. H. McCreery, J. W. Martin, W. T. Wright.

Reedy, Edward Egan, Columbus, Ohio. (Age 25.) Asst. with WPA in Ohio, on material and specification engineering. Refers to C. T. Cavan, C. T. Morris, J. R. Shank, C. E. Sherman, R. C. Sloane.

Remino, Charles Peter, Austin, Tex. (Age 36.) Valuation Engr., Gas Utilities Div., R. R. Comm. of Texas. Refers to C. T. Bartlett, J. S. Fenner, F. S. French, F. E. Giesecke, R. L. Lowry, Jr., H. M. Matthews, T. U. Taylor.

Riales, Roy Lee, McGehee, Ark. (Age 26.) Chf. of Party, U. S. Resettlement Administration. Refers to H. F. Bucher, A. D. Kidder, J. C. Pinney, J. R. Rhyne, W. L. Winters.

Robinson, Paul Edgar, Auburn, N.Y. (Age 21.) Mgr., Jay W. Robinson (sand and gravel business). Refers to E. F. Berry, E. F. Church, L. Mitchell, S. D. Sarason.

Rountree, Seaborn Reuben, Jr., Austin, Tex. (Age 24.) Refers to E. C. H. Bantel, P. M. Ferguson, J. A. Focht.

Savage, Luke Francis, McKeesport, Pa. (Age 57.) City Engr. Refers to V. R. Covell, A. A. Henderson, C. E. Myers, W. W. C. Perkins, C. M. Reppert, E. H. Stumpf.

Scantlebury, Woodman Francis, Port Washington, N.Y. (Age 26.) Senior Engr. and Chf. of Party, Eng. Dept., Nassau County, N.Y.; also Asst. Engr. with A. K. Piloff, Westbury, N.Y. Refers to C. E. Beam, E. L. Macdonald, S. E. Page, F. S. Tainter, S. A. Thoresen.

Schmickle, Robert Donald, Webster Groves, Mo. (Age 30.) Asst. Engr., U. S. Geological Survey. Refers to H. Austill, H. C. Beckman, N. C. Grover, G. A. Hathaway, C. G. Paulsen, F. M. Veatch.

Scott, Albert Lyon, New York City. (Age 58.) Chf. Executive Lockwood Greene Engrs., Inc.; also Cons. Engr. for Pacific, Kendall, and Riverside & Dan River Cotton Mills, U. S. Finishing Co., etc. Refers to C. S. Allen, H. P. Eddy, C. T. Main, J. P. H. Perry, J. F. Sanborn, J. E. Sirrine, S. E. Thompson.

Scranton, Clarence Henry, Knoxville, Tenn. (Age 24.) Jun. Structural Draftsman, TVA. Refers to R. A. Anderegg, H. B. Luther.

Seeley, John Cooley, Ann Arbor, Mich. (Age 25.) Asst. Engr., Michigan State Planning Comm. Refers to A. J. Decker, L. M. Gram, W. C. Hoad, H. W. King, R. L. McNamee, W. C. Sadler, C. O. Wisler.

Shukle, Richard John, Fresno, Calif. (Age 22.) Computer, U. S. Bureau of Reclamation. Refers to C. Derleth, Jr., B. A. Etcheverry, S. T. Harding, C. G. Hyde, C. T. Wiskocil.

Stacey, William Arthur, Hutchinson, Kans. (Age 44.) Field Engr., Service Bureau, American Wood Preservers' Association, Chicago, Ill. Refers to R. C. Keeling, W. C. McNown, R. H. Mann, C. H. Scholer, C. C. Williams.

Starr, John Thornton, Baltimore, Md. (Age 27.) Surveyman, U. S. Engr. Office, Baltimore Dist., War Dept. Refers to T. F. Comber, Jr., H. L. Crandall, P. G. Crout, F. W. Medaugh, J. T. Thompson.

Sturges, Thomas Benedict, Pittsburgh, Pa. (Age 52.) Chf. Engr. and Pres., Pennsylvania Drilling Co. Refers to A. Ackenheil, L. P. Blum, A. C. Clarke, R. P. Forsberg, C. N. Haggart, N. F. Hopkins, J. F. Leonard, D. C. Morrow, J. M. Rayburn, S. A. Taylor, W. A. Weldin.

Sullivan, Francis Xavier, New York City. (Age 25.) Refers to J. J. Costa, A. V. Sheridan.

Sverdrup, Leif John, St. Louis, Mo. (Age 38.) Sverdrup & Parcel, Cons. Engrs. Refers to B. L. Brown, A. S. Cutler, W. W. Horner, O. M. Leland, J. I. Parcel.

Tamargo, Manuel Rafael, Havana, Cuba. (Age 23.) Refers to G. N. Cox, F. J. Gaston, L. J. Muse, B. W. Pegues, F. F. Pillet.

Taylor, Henry George, Portsmouth, Va. (Age 51.) Capt., C.E.C., U. S. Navy; Public Works Officer, Norfolk Navy Yard. Refers to R. E. Bakenhus, G. Church, F. R. Harris, G. A. McKay, J. T. Mathews, P. L. Reed, N. M. Smith.

Tong, George Hong, Los Angeles, Calif. (Age 24.) Refers to R. M. Fox, D. M. Wilson.

Treat, Charles Roland, Jr., Bishop, Calif. (Age 25.) Surveyor's Aide, Dept. of Water & Power, City of Los Angeles, Calif., Mono Basin Extension, Los Angeles Aqueduct, Refers to E. A. Bayley, B. A. Etcheverry.

Tucker, John Paul, Baton Rouge, La. (Age 37.) Designing Draftsman, Dredging Div., U. S. Engrs. Refers to J. H. Brillhart, C. M. Davis, H. B. Friedman, H. M. Hinckley, A. C. Love, F. B. Lovett.

Turnbull, Willard Jay, Hastings, Nebr. (Age 33.) Chf. Soils Engr., The Central Nebraska Public Power & Irrigation Dist. Refers to G. N. Carter, F. T. Darrow, M. I. Evinger, G. E. Johnson, H. J. Kesner, C. E. Mickey, M. C. Noble.

Vose, Arthur Williams, Milton, Mass. (Age 46.) Res. Engr. Inspector, PWA, Boston, Mass. Refers to J. Ayer, C. B. Breed, W. W. Davis, A. W. Dean, L. I. Hewes, J. A. Johnston, T. H. Keenan, W. W. Lewis, C. M. Spofford, D. M. Sullivan, T. F. Sullivan.

Weinberg, Morris, New York City. (Age 20.) Refers to L. V. Carpenter, C. T. Schwarze.

White, David Lindsay, New Orleans, La. (Age 44.) Senior Engr., U. S. Engr. Dept., 2d New Orleans Dist. Refers to F. C. Carey, T. J. Clarke, G. R. Clemens, T. H. Jackson, G. H. Matthes, H. L. Williams, W. P. Wooten.

Wilson, John Thomas, Los Angeles, Calif. (Age 26.) Deputy Bldg. Inspector, Los Angeles County Dept. of Bldg. Refers to M. C. Ayers, R. M. Fox, W. J. Fox, R. J. Kadow, E. Maag, D. M. Wilson, W. T. Wright.

Zipprodt, Roy Richard, White Plains, N.Y. (Age 46.) Associate Prof. of Civ. Eng., Columbia Univ., New York City. Refers to A. B. Cohen, F. R. McMillan, S. S. Neff, F. E. Richart, E. E. Seelye, A. N. Talbot, L. W. Weed.

Zwissler, Gordon Arthur, Chicago, Ill. (Age 22.) Rodman, Chicago, Milwaukee, St. Paul & Pacific R.R. Refers to J. C. Penn, R. L. Stevens.

FOR TRANSFER

FROM THE GRADE OF ASSOCIATE MEMBER

Bowe, Thomas Francis, Assoc. M., New York City. (Elected Nov. 27, 1917.) (Age 50.) Cons. Engr. Refers to G. S. Armstrong, C. A. Emerson, Jr., L. G. Holleran, C. A. Maguire, J. F. Sanborn, W. J. Scott.

Chadwick, Wallace Lacy, Assoc. M., Los Angeles, Calif. (Elected July 6, 1925.) (Age 38.) Senior Engr., The Metropolitan Water Dist. of Southern California. Refers to R. C. Booth, L. V. Branch, H. W. Dennis, J. Hinds, D. H. Redinger, F. E. Weymouth.

Drury, Walter Rhodes, Assoc. M. (Elected Junior Dec. 31, 1913; Assoc. M. Oct. 8, 1918.) (Age 47.) Member of firm, Shoecraft, Drury & McNamee, Cons. Engrs. Refers to L. E. Ayres, J. H. Cissel, L. M. Gram, W. C. Hoad, J. R. Pollock, E. D. Rich, H. E. Riggs.

Grossman, Edmond Eugene, Assoc. M., New York City. (Elected Oct. 14, 1930.) (Age 38.) Management Engr., Gen. Realty & Utility Co. Refers to H. T. Immerman, A. J. Mantica, J. Meltzer, C. T. Schwarze, C. H. Snow.

Hager, Albert Bertram, Assoc. M., Rutherford, N.J. (Elected Nov. 1, 1905.) (Age 56.) 2nd Vice-Pres., Atlantic, Gulf & Pacific Co., Engrs. and Contrs., New York City. Refers to D. D. Barlow, M. S. Falk, P. P. Farley, O. B. Hovey, H. M. Lewis, G. L. Lucas, R. Ridgway, C. E. Trout, A. S. Tuttle, F. P. Witmer.

Kuhn, James Irwin, Assoc. M., Cleveland, Ohio. (Elected April 18, 1916.) (Age 55.) Chf. Engr. and member of firm, Small, Smith & Reeb. Refers to A. A. Burger, F. S. Foulkrod, F. L. Gorman, C. P. Marsh, F. L. Plummer, C. W. Schubert.

Mower, Charles Mason, Jr., Assoc. M., New York City. (Elected Junior Feb. 25, 1924; Assoc. M. Aug. 27, 1928.) (Age 37.) Asst. Engr., The Pitometer Co., Engrs. Refers to E. S. Cole, W. W. Morehouse, H. E. Riggs, A. E. Skinner, B. T. Weston, E. K. Wilson.

NELSON, JABEZ CURRY, Assoc. M., Syracuse, N.Y. (Elected Junior Oct. 1, 1907; Assoc. M. April 7, 1915.) (Age 52.) Pres. and Gen. Mgr., Easy Washing Machine Corporation. Refers to H. Austill, J. A. Emery, L. Mitchell, N. F. Pitts, Jr., W. von Phul.

PICKWORTH, JOHN WILLIAM, Assoc. M., New York City. (Elected Jan. 17, 1921.) (Age 42.) Member of firm, Weiskopf & Pickworth, Cons. Engrs. Refers to R. L. Bertin, F. H. Frankland, C. B. Spencer, J. W. Taussig, A. Weymouth, W. H. Yates.

PRICHARD, MASON CARTER, Assoc. M., Ocala, Fla. (Elected Aug. 15, 1932.) (Age 37.) Prin. Asst. to Dist. Engr., U. S. Engr. Office. Refers to C. E. Boesch, F. C. Carey, W. J. Douglas, W. G. Grove, M. Pirnie, B. B. Somervell, D. S. Wallace.

REEVES, ARTHUR BLAINE, Assoc. M., Denver, Colo. (Elected July 15, 1929.) (Age 50.) With U. S. Bureau of Reclamation, North Platte Project. Refers to H. W. Bashore, E. B. Debler, H. R. McBirney, W. H. Nalder, J. L. Savage, R. F. Walter, A. Weiss.

WEISKOPF, WALTER HERBERT, Assoc. M., New Rochelle, N.Y. (Elected Junior March 7, 1921; Assoc. M. March 16, 1925.) (Age 37.) Member of firm, Weiskopf & Pickworth, Cons. Engrs., New York City. Refers to R. L. Bertin, C. W. Dunham, F. H. Frankland, F. C. Moore, J. E. Wadsworth, W. H. Yates.

WELLS, JAMES BERTRAND, Assoc. M., Palo Alto, Calif. (Elected Junior Jan. 7, 1913; Assoc. M. July 6, 1920.) (Age 47.) Associate Prof. of Civ. Eng., Stanford Univ., Stanford University, Calif. Refers to M. C. Collins, J. C. L. Fish, H. H. Hall, S. B. Morris, W. H. Popert, L. B. Reynolds, S. K. Whipple.

FROM THE GRADE OF JUNIOR

BINGLEY, WILLIAM MCLEAN, Jun., Atlanta, Ga. (Elected Oct. 14, 1929.) (Age 29.) Sales Engr., The Dorr Co., Inc., New York City. Refers to D. S. Abell, F. Bachmann, E. B. Besselievre, L. H. Enslow, J. H. Gregory, W. M. Piatt, J. T. Thompson.

BOND, JOHN HENRY, JR., Jun., Bethlehem, Pa. (Elected Nov. 15, 1926.) (Age 32.) Estimator and Designer, McClintic Marshall Co. and Bethlehem Steel Co. Refers to E. F. Ball, S. W. Bradshaw, E. L. Durkee, J. Farenwald, A. R. Graves, W. H. Jameson, J. Jones.

CONNELL, GILBERT FETTERMAN, Jun., Zanesville, Ohio. (Elected Nov. 10, 1930.) (Age 32.) Prin. Draftsmen-Asst. Engr., in charge of Gen. Eng. Sec., U. S. Engr. Office. Refers to G. H. Friend, D. P. Grosshans, F. B. Harkness, T. T. Knappen, E. L. Winslow, Jr.

COURTER, JOSEPH ALLAN, Jun., Montclair, N.J. (Elected June 6, 1927.) (Age 32.) Engr., Long Lines Dept., American Telephone & Telegraph Co., New York City. Refers to W. S. Baver, H. N. Cummings, A. F. Eschenfelder, H. R. Gabriel, W. S. LaLonde, Jr.

DRURY, WILLIAM GEORGE, Jun., Morristown, N.J. (Elected Dec. 3, 1928.) (Age 32.) Asst. Engr., Valuation Dept., Federal Water Service Corporation and New York Water Service Corporation, New York City. Refers to G. S. Beal, H. M. Huy, H. G. Payrow, A. Schultheis, P. A. Shaw.

DURRETT, THOMAS JACKSON, JR., Jun., Atlanta, Ga. (Elected Dec. 3, 1926.) (Age 31.) Supervisor of Operations and Dist. Director, Dist. No. 5. (Fulton and DeKalb Counties), WPA of Georgia. Refers to L. F. Bellinger, G. P. Donnellan, W. A. Hansell, R. L. MacDougall, M. T. Singleton, F. C. Snow.

EVANS, THOMAS HAYHURST, Jun., Charlottesville, Va. (Elected Dec. 22, 1930.) (Age 30.) Asst. Prof., Dept. of Eng., Univ. of Virginia. Refers to W. J. Cox, P. G. Laurson, J. L. Newcomb, F. Thomas, C. J. Tilden, E. K. Timby.

FLICKINGER, LLOYD HENRY, Jun., Minneapolis, Minn. (Elected Oct. 1, 1928.) (Age 32.) Asst. Engr., Minneapolis-St. Paul San. Dist., St. Paul, Minn. Refers to F. Bass, W. N. Carey, W. H. Dittoe, A. J. Duvall, H. M. Hill, H. B. Pettit, A. L. Reeder.

GLUCKERT, WILLIAM JOHN, JR., Jun., Caripito, Venezuela. (Elected Jan. 18, 1926.) (Age 32.) Chf. Draftsman, Standard Oil Co. of Venezuela, Maracaibo, Venezuela. Refers to F. H. Bailly, T. Buckley, B. Franklin, A. W. Green, Jr., A. Z. Hoffman, C. W. O'Connell, J. R. Stubbins, A. W. Tolander.

IRVINE, JAMES OSBORNE, Jun., East Orange, N.J. (Elected Oct. 30, 1933.) (Age 33.) Project Supt., U. S. Dept. of Agriculture (New Jersey State Dept. of Conservation and Development), Pequannock Watershed, Butler, N.J. Refers to M. A. Butler, H. R. Gabriel, C. Gilman, N. H. Jones, H. A. Philip, W. H. Robertson, C. H. Splitstone.

LEWIS, ALF ALLEN, Jun., Denver, Colo. (Elected May 13, 1929.) (Age 30.) Associate Engr., U. S. Bureau of Reclamation. Refers to S. F. Crecelius, O. N. Floyd, A. W. Kidder, J. J. Ledbetter, Jr., J. L. Lochridge, H. R. McBirney, C. P. P. Vetter.

MACA, LEON FRANCIS, Jun., Ogden, Utah. (Elected Oct. 1, 1928.) (Age 31.) Chf. of Field Party, U. S. Forest Service. Refers to H. H. Hodgeson, A. Johnson, J. P. Martin, R. G. Stevenson, R. R. Zack.

MACPHERSON, MALCOLM, Jun., Stamford, N.Y. (Elected Dec. 5, 1927.) (Age 32.) Asst. Engr., Delaware County Highway Dept., Delhi, N.Y. Refers to C. B. Ferris, H. Hartwell, W. J. Howland, G. Parker, R. H. Scott.

OREM, HOLLIS MILON, Jun., San Francisco, Calif. (Elected March 11, 1929.) (Age 32.) Asst. Engr., Water Resources Branch, U. S. Geological Survey. Refers to R. C. Briggs, R. K. Brown, G. H. Canfield, J. C. Hoyt, H. D. McGlashan, K. N. Phillips, M. Sullivan.

PIROK, JOHN NICHOLAS, Jun., Glasgow, Mont. (Elected Oct. 26, 1931.) (Age 32.) Asst. to Chief Engineer, Ft. Peck Dam, Chicago, Ill. Bridge & Iron Works. Refers to H. Cross, J. J. Doland, M. L. Enger, J. J. Hammond, W. C. Huntington, H. H. Jordan, N. D. Morgan, C. E. Palmer, L. G. Puls, F. E. Richart, H. W. Tabor, L. C. Tschudy, W. M. Wilson.

SYMNS, SAMUEL YOUNG, Jun., Monrovia, Liberia, West Africa. (Elected Oct. 26, 1931.) (Age 31.) With Firestone Plantations Co. Refers to W. Bowie, J. W. Bulger, M. L. Davis, R. C. Durst, C. L. Garner, C. F. Maynard.

THAYER, GEORGE MOORE, Jun., Puyallup, Wash. (Elected Nov. 12, 1928.) (Age 30.) Constr. Engr., Tacoma Dist., Water Resources Branch, U. S. Geological Survey. Refers to C. J. Bartholet, G. H. Canfield, N. C. Grover, W. A. Kunigk, G. L. Parker, C. G. Paulsen, B. P. Thomas.

WATTS, JOSEPH CLYDE, Jun., Detroit, Mich. (Elected Oct. 10, 1927.) (Age 32.) Chf. of Party, U. S. Engr. Office. Refers to F. W. Dencer, C. Y. Dixon, C. J. Kennedy, C. E. Palmer, I. O. Thorley, M. F. Wagnitz.

WHITE, SARGENT, Jun., Arlington, Va. (Elected Nov. 23, 1931.) (Age 29.) Civ. Engr. (private practice). Refers to R. W. Berry, F. A. Biberstein, H. A. Hook, A. J. Scullen, G. E. Stratton.

The Board of Direction will consider the applications in this list not less than thirty days after the date of issue.

Men Available

These items are from information furnished by the Engineering Societies Employment Service, with offices in Chicago, New York, and San Francisco. The service is available to all members of the contributing societies. A complete statement of the procedure, the location of offices, and the fee is to be found on page 87 of the 1936 Year Book of the Society. To expedite publication, notices should be sent direct to the Employment Service, 31 West 39th Street, New York, N.Y. Employers should address replies to the key number, care of the New York Office, unless the word Chicago or San Francisco follows the key number, when it should be sent to the office designated.

CONSTRUCTION

CONSTRUCTION ENGINEER AND SUPERINTENDENT; M. Am. Soc. C.E.; M. Can. Inst. C.E.; professional engineer and land surveyor, New York and New Jersey; wide experience on construction of tunnels, compressed air, vehicular, and rock; subways, sewerage and water systems, reservoirs, and heavy construction of all kinds. Salary depends on location. D-5015.

CONSTRUCTION ENGINEER AND SURVEYOR; Assoc. M. Am. Soc. C.E.; 35; married; C.E., Princeton University; 8 years railroad surveys on construction and maintenance; 3 years varied experience in construction, valuation, drafting, etc. Especially qualified for layout and supervision of construction and handling survey parties. Location immaterial. Detailed experience record sent on request. D-1027.

CONSTRUCTION ENGINEER-ESTIMATOR; Assoc. M. Am. Soc. C.E.; architectural graduate; 3 years civil engineering study; 38; married; 7 years experience in construction departments of major oil company, public utility corporation, and industrial companies in field supervision and office engineering; 9 years with large construction companies as building cost estimator, construction engineer, and in purchasing and contact work. Available. C-2146.

CONSTRUCTION ENGINEER; Assoc. M. Am. Soc. C.E.; 40; married. Registered professional engineer; broad experience in all forms of construction; specialist in concrete and roadbuilding; good organizer and administrator. Former contractor and can qualify as office manager, field superintendent, or public relations man. Best references. Available immediately. West coast preferred. D-5324-368-A-2 San Francisco.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 36; married; licensed engineer, Ohio; 14 years diversified experience; estimating and supervising building construction; also city water works and sewage disposal; concrete dam and rolled, earth-fill dam. Desires connection with active engineering or construction organization. Employed now. Available on reasonable notice. D-5352.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 29; single; graduate of New York University, 1930; registered professional engineer, New York; 8 years with contractor on subway and vehicular tunnels; field engineer and assistant to chief engineer on subsurface construction, in compressed air, hydrographic dredging, surveying, etc. Desires work with contractor on new construction. Employed. Available on short notice. D-1921.